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INSTRUCTIONS
FOR THE PREPARATION OF
ARTILLERY METEOR REPORTS

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INSTRUCTIONS FOR THE PREPARATION OF
ARTILLERY METEOR REPORTS

PART I

METEOR REPORTS FOR GUNNERY AGAINST SURFACE TARGETS

§1. INTRODUCTION

A shell fired from a gun follows an approximately parabolic path through the air before arriving at the point of impact, and the range and deviation of the shell depend on the winds and densities at different heights along the trajectory. The range tables used by the artillery give the ranges obtained, along the line of fire, under standard atmospheric conditions. Errors in range and deviations from the line of fire due to variations from standard conditions are, in general, too large to be neglected, and arrangements are made to supply artillery units with meteorological data, appropriate to the position of the battery and the time of firing, to enable them to make the necessary corrections.

Meteorological observations or forecasts of meteorological conditions at various heights cannot be used directly for this purpose. It is necessary to reduce the observations or forecasts to a form in which they can be readily applied in the field to trajectories reaching different heights in the atmosphere. This part of the pamphlet describes in detail the procedure to be followed for reducing observations and forecasts for meteor reports supplied for use in gunnery against surface targets. A brief description of the principles of the method is included. Fuller accounts of the theory of the method are given in text-books on ballistics.

§2. THE PRINCIPLES OF THE METHOD

The standard ballistic atmosphere.—The range tables used by the Artillery give the ranges obtained along the line of fire in a standard atmosphere called the Standard Ballistic Atmosphere. The meteorological conditions of the Standard Ballistic Atmosphere, as revised in 1941, are given below. The characteristic features of this atmosphere are:—

- Still air.
- Sea-level pressure, 30 in. Hg at 32° F. in latitude 45° (1015.9 mb.).
- Sea-level temperature, 60° F. (519.4° F. Absolute).
- Standard temperatures in the troposphere as given in Table VII.
- Standard temperature of the stratosphere, -56.2° F. (403.2° F. Absolute, 224.0° C. Absolute).
- Standard height of the tropopause, 35,000 ft.
- Relative humidity, 50 per cent. at all heights in the troposphere and stratosphere (vapour pressure 0.261 in. or 8.84 mb. at sea level at 60° F.).
- Air density at sea level, 534.2 grains per cubic foot (2.288 gm. per cubic metre).

(i) Vertical distribution of air density in the troposphere given by

$$\log_{10} \rho_0 / \rho = 0.141 h / 10,000$$

in which

ρ_0 = the standard sea-level density ;

ρ = the density at the height h ;

h = the height above sea level in feet (not greater than 35,000 ft.).

(j) Standard vertical distribution of density in the stratosphere given by :—

$$\log_e \rho / \rho_0 = \log_e \frac{\rho(35000)}{\rho_0} - \frac{g_0 \rho_0 T_0}{T_s (\rho_0 - \frac{2}{3} \epsilon_0)} (h - 35000) \left(1 - \frac{h + 35000}{E} \right)$$

in which

ρ_0 and ρ are defined as in (i) ;

h = the height above sea level in feet (greater than 35,000 ft.) ;

p_0 = the standard sea-level pressure ;

T_0 = the standard sea-level temperature in °F. Absolute ;

T_s = the standard temperature of the stratosphere in °F. Absolute ;

ϵ_0 = half the vapour pressure of water at a temperature T_0 ;

g_0 = the standard ballistic acceleration due to gravity 32.19 ft. sec. sec. ;

E = the radius of the earth, 2.0882×10^7 ft. in the latitude of Greenwich ;

(k) Standard velocity of sound, 1,120 ft. sec. (34,136 cm. sec.) in half saturated air at 60° F.

The standard air density at sea level (h) is the density of air under the standard sea-level conditions of pressure, temperature and humidity (b), (c) and (g).

The standard temperatures of the troposphere (d) are obtained by calculation from the formula for the standard vertical distribution of density (i) using the usual equation of state and including the standard humidity distribution (g). The standard temperatures are in general considerably higher than the average temperatures in the troposphere over the British Isles.

The standard temperature at all heights in the stratosphere (e) is the standard temperature at 35,000 ft. calculated in the same way as the temperatures in the troposphere. The value agrees very well with the average temperature of the stratosphere over south-east England.

The standard vertical distribution of density in the stratosphere (j) is determined from the usual hydrostatic equation and the equation of state assuming that the temperature in the stratosphere is everywhere the same and that the air is half saturated.

Wind.—The wind always varies with height and the effect of a wind on the range and deviation of a shell at the point of impact differs according to the point in the trajectory at which the wind is operating. For the preparation of meteor reports the layer of air between the ground and the vertex of the trajectory is divided into a convenient number of sub-layers, and the mean components of the wind in the sub-layers are multiplied by appropriate weighting factors to allow for the relative effect of the wind in each sub-layer. The sum of the weighted winds taken over the whole layer gives a weighted mean wind for the complete trajectory. The weighted mean wind is called the equivalent constant wind (E.C.W.). It has the same effect on the range and deviation of the shell as the different winds actually operating at different heights in the trajectory.

The range tables give the correction to the range in yards due to a uniform wind, the velocity of which is given, and which blows along the line of fire at all heights. To obtain the correction to range at the time of firing the E.C.W.

is resolved along the line of fire and the correction is calculated from the figure given in the range table in proportion to the component of the velocity. Similarly, the range tables give the deviation of the line of fire in degrees and minutes due to a uniform cross wind of given velocity, blowing at right angles to the line of fire at all heights, and to obtain the required correction to line, the E.C.W. is resolved perpendicular to the line of fire and the deviation calculated in proportion to the cross component of the velocity.

Density.—The density of the air at all heights depends on the pressure and on the vertical distribution of temperature and humidity, and the density varies according to the variations of these elements with time and place. The effect of a variation of density is to increase or decrease the range, and corrections for a uniform proportional variation from the standard can be calculated. The actual variation of density with height at any time can also be reduced to an equivalent uniform proportional variation of density and expressed in the form of a tenuity factor (τ). It is more convenient, however, for use in the field, to apply a separate correction for pressure and a combined correction for temperature and humidity. The necessary data to obtain density corrections is therefore supplied in meteor reports in terms of pressure and temperature. The tenuity factor for any particular trajectory can always be calculated from the temperature and pressure data given in the meteor report, if required, by means of the following formula :—

$$\tau = \frac{519.4 P}{30.00 (459.4 + T_b)}$$

in which

τ = the tenuity factor ;

P = the barometric pressure in in. Hg at the gun position ;

T_b = the ballistic temperature (see below) ;

30.00 = the standard surface pressure in in. Hg ;

519.4 = the standard surface temperature in °F. Absolute ;

459.4 = zero F. in °F. Absolute.

The corrections for variations of tenuity can be obtained from the range tables in the column headed "Corrections for 1 per cent. change of C" (Ballistic Coefficient). The correction for a 1 per cent. variation of the tenuity factor from unity is the same as a 1 per cent. variation of the ballistic coefficient but opposite in sign.

It will be found that the correction for tenuity differs from the combined corrections for temperature and pressure. This is due to the fact that the temperature correction given in the range tables includes a correction for elasticity variations.

Pressure.—If the vertical distribution of temperature and humidity is kept constant, the density of the air at any height will vary in the same ratio as variations of the surface pressure. Density variations in any trajectory, at all points in the trajectory, due to variations of pressure, are therefore completely determined by the surface pressure. Corrections are given in the range tables for a specified variation of the surface pressure from the standard, and to enable the appropriate corrections to be applied for batteries at different levels the pressure at M.S.L. is given in the meteor report. The surface pressure at the battery position is obtained by the battery staff by subtracting 1 in. Hg from the pressure at M.S.L. for every 1,000 ft. above M.S.L.

Temperature.—If the amount of water vapour and the surface pressure are kept constant, the density of the air at all heights will depend on the vertical distribution of temperature. A variation of temperature from the standard at any height produces a variation of density from the standard at that height, and also a variation of density at any greater height proportional to the density at that greater height. Further, as in the case of corrections for upper winds,

the effect of a variation of density on the range of a shell at the point of impact differs according to the point in the trajectory at which the density variation occurs.

Reduction of the observations or forecasts of upper air temperatures, for density variations due to temperature, is carried out in much the same way as the reduction of wind observations. The layer of air between the ground and the vertex of the trajectory is divided into a convenient number of sub-layers, and the standard temperature corresponding to the mid height of each sub-layer is subtracted from the observed temperature at each height. The differences are multiplied by weighting factors appropriate to each layer, and the algebraic sum of the products is added to the standard surface temperature of 60° F.

The temperature obtained is called the ballistic temperature (B.T.). It is the surface temperature in an atmosphere in which the lapse rate is such that the proportional variation of density from standard is the same at all heights and would have the same effect on range as the variations of density due to the existing temperature distribution. The variation in range due to the existing temperature distribution is proportional to the difference between the B.T. and 60° F.

The range tables give the corrections in range to be applied when the B.T. differs from the standard surface temperature by 10° F. and the correction for other values of the B.T. are obtained proportionally.

It is of interest to note—

(1) that the calculation of the B.T. for a given trajectory takes into account the variations of density above the height at which a given temperature variation occurs; and

(2) that the sum of the temperature weighting factors for a given trajectory is less than unity, and, in general, the sum decreases as the height of the trajectory increases.

The explanation is broadly as follows:—Air temperature variations are significant only in so far as they affect the air density. The B.T. is used to compute this effect on the assumption that surface pressure remains constant. (Allowance for pressure variation is made separately.) Now it is clear that an increase in temperature in one individual layer will cause a decrease in density in that layer. Since the surface pressure remains constant the density in higher layers must increase.

Now if a density weighting factor were used and defined as the fraction of the total effect produced by a constant percentage variation in density throughout the trajectory which is contributed by the effect of this density change in the given layer, the temperature weighting factor for a given layer will be equal to the density weighting factor for that layer minus a fraction of the density weighting factor for each higher layer of the trajectory, the exact fraction depending upon the ratio of the density change in the layer being considered to the compensating change in the reverse direction in the higher layer. But since the density weighting factors necessarily add up to unity it is clear that the sum of the temperature weighting factors must be less than unity. Moreover it can be shown that the compensating effect in the higher layers which accompanies a temperature change in one specific layer increases as the height of the vertex increases. Hence the sum of the temperature weighting factors decreases as the vertex height increases.

Humidity.—The density of water vapour is less than that of air, and the density of air containing water vapour is therefore less than that of dry air at the same temperature and pressure. Variations of humidity thus produce variations of density, and the effect, though relatively small, is not always negligible. Since the standard humidity assumed in the ballistic atmosphere is 50 per cent., the correction required will be largest when the air is either saturated or dry. At temperatures below 0° F. the saturation vapour pressure

is small and the effect is negligible for all values of the relative humidity. The effect becomes larger as the saturation vapour pressure increases with increasing temperature, and it is greatest in the tropics.

Corrections for the variation of humidity at any height from the standard of 50 per cent. are applied by making a suitable correction to the observed or forecast temperatures before calculating the B.T. The value of the correction to be applied to the temperature depends on the temperature and the height, and is obtained from Table VI. This "adjusted" temperature is the temperature required to keep the density unchanged when the relative humidity is changed to 50 per cent.

Elasticity.—The range of a shell at the point of impact depends on the elasticity of the air as well as on the density, and since the elasticity varies with the temperature, a variation of temperature from the standard at any point in the trajectory of the shell will produce a variation in range, not only by altering the density, but also by altering the elasticity.

As a shell moves through the air, it compresses the air immediately in front of it, and, owing to the elastic properties of the air, this compression travels through the air at a velocity equal to that of sound. If the velocity of the shell is less than that of sound the compression will be propagated in advance of the shell. If the velocity of the shell is greater than that of sound the shell will outpace the compression. If the velocity of the shell is equal to or near that of sound the compression will be continually reinforced and there will be a corresponding increase in the resistance of the air to the motion of the shell. Now the velocity of sound depends on the elasticity of the air which in turn depends upon the temperature. Therefore the resistance of the air due to its elasticity makes itself felt when the velocity of the shell passes through the velocity of sound, and it is a function of the air temperature.

The effect of elasticity variations on the range of a shell can be evaluated in the same way as the effect of density variations due to variations of temperature. The layer of air between the ground and the vertex of the trajectory is divided into a convenient number of sub-layers, and the standard temperature, corresponding with the standard value of the elasticity (or velocity of sound) at the height of the mid point of each sub-layer, is subtracted from the observed temperature at each mid height. The differences are multiplied by elasticity weighting factors appropriate to each sub-layer, and the algebraic sum is added to or subtracted from the standard surface temperature of 60° F.

The temperature obtained is called the elasticity temperature (E.T.). It is the surface temperature in an atmosphere in which the lapse rate is such that the proportional variation of density from standard is the same at all heights and would have the same effect on range as the variation of elasticity due to the existing temperature distribution. The variation in range is proportional to the difference between the E.T. and 60° F.

The E.T. is only evaluated in experimental firings. For gunnery in the field it is assumed that the E.T. is always equal to the B.T., and the corrections given in the range tables for a specified variation of the B.T. includes the corrections for elasticity variations. It is therefore unnecessary to calculate the E.T. for gunnery in the field.

Mean weighting factors.—The weighting factors for wind and temperature differ according to the height of the trajectory, the type of gun used, and the type of shell. The weighting factors for cross winds also differ from those for winds along the line of fire. To obtain the best results E.C.Ws. and B.Ts. should therefore be calculated for individual trajectories, and separate E.C.Ws. should be calculated for the line and cross wind components along any line of fire.

This procedure is not normally practicable under operational conditions. For gunnery in the field mean weighting factors are used, which are obtained by grouping and averaging the weighting factors applicable to all guns and shells.

The trajectories are grouped according to the time taken by the shell to traverse the complete trajectory. This time is called the time of flight (T.F.) and it is found that all trajectories, which have the same T.F., reach approximately the same vertex height. A convenient series of T.Fs. is selected, and the corresponding heights, which extend up to the greatest heights reached by most of the heaviest guns, are each divided into a convenient number of sub-layers. The mean weighting factors for the sub-layers of each height are then obtained by averaging the weighting factors in the corresponding sub-layers of all the trajectories in each group.

In obtaining the mean wind weighting factors, the line wind and cross wind factors are meaned together. The mean factors can therefore be applied to components of the wind in any direction, irrespective of the line of fire, and the velocity and direction of an E.C.W., obtained by weighting the E. and N. components of the observed winds, can therefore be resolved along and across any line of fire to obtain the appropriate corrections for line and cross winds.

The mean weighting factors for wind and temperature are given in Tables II and III, and it is of interest to note that they are greatest in the highest layers, which means that on the average the wind and temperature near the top of a trajectory have a greater influence on the range and deviation of a shell than the winds and temperatures in the lower layers.

Vertex height and time of flight.—Trajectories which have the same T.F. reach approximately the same vertex height, irrespective of the range. The height is given by the formula:—

$$H = 4 T^2$$

in which

H = the vertex height in feet, and

T = the time of flight in seconds.

The following table gives the T.Fs. for which mean weighting factors have been obtained, and the corresponding vertex heights. The number and thickness of the sub-layers used for each height are also given.

Time of flight	Height of vertex	Thickness of sub-layer	Number of sub-layers
<i>sec.</i>	<i>ft.</i>	<i>ft.</i>	
5	100	—	—
10	400	—	—
20	1,600	500	3
30	3,600	2,000	2
40	6,400	2,000	3
50	10,000	2,000	5
60	14,400	2,000	7
70	19,600	4,000	5
80	25,600	4,000	7

It will be seen from the table that the sub-layers used do not exactly divide the heights of the vertices of the trajectories. This is necessary in order to simplify the weighting of the forecast winds. The approximation is sufficiently accurate for the preparation of operational meteor reports.

The winds and temperatures for T.Fs. 5 and 10 sec. are not weighted in quite the same way as the other T.Fs. Particulars of the method employed are given in the sections dealing with the computation of the E.C.Ws. and B.Ts.

An E.C.W. and a B.T. is calculated for each T.F., using the appropriate mean weighting factors, and the values obtained, together with a measurement of the pressure at M.S.L., are transmitted to the artillery units in the form of a coded telegram. The time of flight corresponding to any required range is given in the range tables, and the appropriate E.C.W. and B.T. for that range can be readily obtained by interpolation from the meteor telegram. The pressure at M.S.L. given in the telegram applies to all ranges, after it is corrected to allow for the height of the battery.

§3. METEOROLOGICAL DATA FROM OBSERVATIONS AND FORECASTS

Basic information.—Ideally a meteor report should be based upon winds and temperatures measured near the gun immediately prior to the shoot. Under operational conditions this is seldom possible. Frequently the nearest place at which observations have been made is an appreciable distance away and, owing to communication delays in passing the report to the gunner this will involve a considerable interval between the time of the observation and the time of application of the meteor report by the gunner. In such circumstances a forecast of the mean winds, temperatures and humidities for the sub-layers for the various T.Fs. and of M.S.L. pressure applicable to the site of the gun and the mid time of the period during which the meteor report will be used, should be obtained from the appropriate forecast centre. These forecast values should then be treated in the way described below for dealing with observations. The forecast values should be obtained sufficiently in advance of the period of applicability to allow the meteor to be computed and transmitted to the gunner before the beginning of the period.

For shoots other than those taking place under operational conditions it may be possible to arrange for observations to be made near the gun just before the shoot takes place. In these circumstances observations should be made as described below.

Pilot-balloon observations.—A pilot-balloon ascent should be carried out immediately before the time of issue of the report allowing sufficient time for the observations, computations and coding before the report is due. The reports should be issued punctually. The tail method should be used for the pilot-balloon ascent. Instructions for the use of the tail method will be found in M.O. 396, "The measurement of upper winds by means of pilot balloons." Enter the observations on Form 2081, including all the information required at the top of the form. For use in the preparation of meteor reports it will be necessary to compute the ascent only as far as the components $V_{W \text{ to } E}$ and $V_{S \text{ to } N}$. The components obtained will be in 100 ft. min. units and they should be given to the nearest tenth.

Surface wind measurements.—After the pilot-balloon ascent measure the surface wind velocity with a cup anemometer mounted 15 ft. above the ground, taking a run of at least two minutes. The anemometer should be carefully exposed on an open site. Obtain the direction of the surface wind by observing the azimuth of the balloon ten seconds after its release. The wind direction is obtained by adding 180° to the bearing of the balloon. Enter the results at the top of Form 2081 and give the velocity in ft. sec. units. At a station where a velocity and direction recorder is available, the surface wind velocity and direction should be taken from the record. A correction for the height of the head of the recorder need not be applied unless the head is exceptionally high; the necessary correction can be obtained from p. 43 of the Meteorological Observer's Handbook (M.O. 191, 1939 Edition).

Surface temperature and humidity measurements.—Observe the screen temperature, dry and wet, after the pilot-balloon ascent. The temperatures should be obtained with thermometers of M.O. pattern, exposed in a Stevenson or Marine type screen, in accordance with the instructions given in the Meteorological Observer's Handbook (M.O. 191). The temperatures will be measured to the nearest degree F. and entered at the top of Form 2081, together with the relative humidity.

Barometer.—The barometer should be read after the pilot-balloon ascent. The reading should be corrected to M.S.L., converted from millibars to inches and entered to the nearest hundredth of an inch at the top of the pilot-balloon form. The barometer should be mounted and observed, and the readings corrected in the manner described in the Meteorological Observer's Handbook. Readings of an aneroid may be used when a mercury barometer is not available.

To reduce the readings of an aneroid to M.S.L. for the purpose of an operational meteor report it is sufficient to add a correction in the proportion of 1.0 in. Hg to 1,000 ft.

It should be noted that an aneroid requires careful treatment and it should frequently be checked against a standard, preferably a mercury standard. The mercury barometer reading should be corrected for temperature, index error and latitude but not reduced to M.S.L. for this comparison.

Forecast winds, temperatures and humidities in the upper air.—Forecasts of winds, temperatures and humidities in the upper air for the heights and for the period for which this information is required in the computation of meteor reports should be obtained from the appropriate forecast centre.

§4. COMPUTATION OF S.T. METEOR REPORTS

Equivalent constant winds.—The computation of the E.C.W. for each T.F. will be carried out in the sections provided in the upper half of Form 2087 (see Appendix I). The following tables will be required:—

Table IA .. Resultants and components in the same units.

Table II .. Wind weighting factors for S.T. meteor reports.

Table IX .. Conversion of m.p.h. to ft. sec. units.

Although most operational meteors will be based upon forecast values of wind and temperature and humidity, the results from a suitable pilot-balloon ascent will sometimes be available. On other occasions suitable pilot-balloon results may be available up to a height which is lower than the vertex of the trajectory and these results must then be supplemented by forecast winds for the greater heights.

When forecast winds are used enter the forecast value of the wind, in ft. sec. units and degrees from true north, at the mid point of the layer in the appropriate spaces on Form 2087. Compute the components of these winds from Table IA and enter in the columns headed Mean Components. If pilot-balloon results are used the mean components can be obtained from the pilot-balloon form. In the column giving the height of the pilot balloon on the pilot-balloon sheet look for the heights nearest to the upper and lower boundaries of each of the various layers used on Form 2087 (i.e. the heights in the columns headed "Height in 1,000's of feet"). Having selected these heights subtract the values of D_E and D_N for the lower height from the values for the greater height and divide each difference by the number of minutes taken by the balloon to rise from the lower to the greater height. The answers are the mean components in 100 ft. min. units. These components should be converted to ft. sec. units by multiplying by 10 and dividing by 6. They should then be entered on Form 2087.

It will sometimes be necessary to interpolate between the surface wind and the wind at 1,000 ft. to obtain the wind at the mid points of the layers for T.F. 10 sec. and T.F. 20 sec. If there is a large difference between the wind at surface and at 1,000 ft. the process of interpolation should be applied to the components.

Multiply the mean components in each layer by the appropriate weighting factors obtained from Table II. It should be noted that the same weighting factor is used for both components in any sub-layer of a given trajectory. Enter the products in the columns headed with the respective T.Fs. together with their positive or negative signs. Obtain the algebraic sums of the products and enter them in the spaces provided. The sums are the components of the E.C.Ws. in ft. sec. units. Obtain the velocity and direction of the E.C.Ws. in ft. sec. units and degrees (T.B.) with the use of Table IA, using the rules given in Note 3 below the table to obtain the direction. Enter the E.C.Ws. on the form.

TABLE IA—RESULTANTS AND COMPONENTS IN THE SAME UNITS.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	45	27	18	14	11	9	8	7	6	6	5	5	4	4	4	4	3	3	3	3	3	3	2	2	2	2	2	2	2	2
2	45	34	27	22	18	16	14	13	11	10	9	9	8	8	7	7	6	6	5	5	5	5	5	4	4	4	4	4	4	4
3	45	37	31	27	23	21	18	17	15	14	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
4	45	39	34	30	27	24	22	20	19	17	16	15	14	13	12	11	10	10	9	9	8	8	7	7	6	6	5	5	4	4
5	45	40	36	32	29	27	24	23	21	20	19	18	17	16	15	14	13	12	11	11	10	10	9	8	8	7	6	6	5	4
6	45	41	37	34	31	29	27	25	23	22	21	20	19	18	17	16	15	14	13	12	12	11	11	10	10	9	8	7	6	5
7	45	41	38	35	32	30	28	26	24	23	22	21	20	19	18	17	16	15	14	13	12	12	11	11	10	10	9	8	7	6
8	45	42	39	36	34	32	30	28	26	24	23	22	21	20	19	18	17	16	15	14	13	12	12	11	11	10	10	9	8	7
9	45	42	39	36	34	32	30	28	26	24	23	22	21	20	19	18	17	16	15	14	13	12	12	11	11	10	10	9	8	7
10	45	42	40	38	36	34	32	30	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	11	10	10	9
11	45	43	40	38	36	34	32	30	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	11	10	10	9
12	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
13	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
14	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
15	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
16	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
17	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
18	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
19	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
20	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
21	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
22	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
23	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
24	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
25	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
26	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
27	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
28	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
29	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
30	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
31	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
32	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
33	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
34	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
35	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
36	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
37	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
38	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
39	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
40	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
41	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
42	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
43	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
44	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
45	45	43	41	39	37	35	34	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10

NOTE 1

Angles in Italics

RESULTS IN CLARENDON

NOTE 2

For components larger than those shown halve both components; use these halved values in the table and double the resultant speed, but not the angle.

NOTE 3

If "A" is the angle given by the table, following are rules for obtaining actual wind direction in degrees measured from North:-

$$V_i - V_N - \left\{ \begin{matrix} V_i < V_N \\ V_i > V_N \end{matrix} \right. \begin{matrix} A \\ 90-A \end{matrix} \quad V_i + V_N + \left\{ \begin{matrix} V_i < V_N \\ V_i > V_N \end{matrix} \right. \begin{matrix} 180+A \\ 270-A \end{matrix}$$

$$V_i - V_N + \left\{ \begin{matrix} V_i > V_N \\ V_i < V_N \end{matrix} \right. \begin{matrix} 90+A \\ 180-A \end{matrix} \quad V_i + V_N - \left\{ \begin{matrix} V_i > V_N \\ V_i < V_N \end{matrix} \right. \begin{matrix} 270+A \\ 360-A \end{matrix}$$

NOTE 4

To obtain components V_L and V_C along and across the line of fire, subtract the line of fire from the wind direction and add 360° if the difference is negative. If "R" is the angle obtained and if "B" is an angle less than 45°, the following gives V_L and V_C and their appropriate signs:-

$$R < B \quad V_L < V_C \quad V_L - V_C \quad R = 180-B \quad V_L < V_C \quad V_L + V_C$$

$$R > B \quad V_L < V_C \quad V_L + V_C \quad R = 270-B \quad V_L < V_C \quad V_L + V_C$$

$$R < B \quad V_L > V_C \quad V_L - V_C \quad R = 180-B \quad V_L > V_C \quad V_L + V_C$$

$$R > B \quad V_L > V_C \quad V_L + V_C \quad R = 270-B \quad V_L > V_C \quad V_L + V_C$$

26	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
27	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
28	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
29	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26</																									

The E.C.W. for T.F. 5 sec. should be computed after the E.C.W. for T.F. 10 sec. The velocity of the E.C.W. for T.F. 5 sec. is given by the formula :—

$$V_5 = V_s + \frac{1}{4} (V_{10} - V_s)$$

in which V_5 is the velocity of the E.C.W. for T.F. 5 sec., V_s is the velocity of the surface wind and V_{10} is the velocity of the E.C.W. for T.F. 10 sec. The direction of the E.C.W. for T.F. 5 sec. is the arithmetic mean of the surface wind direction and the direction of the E.C.W. for T.F. 10 sec.

A table of products of weighting factors and wind components is given in Appendix IV.

Ballistic temperatures.—The computation of the B.Ts. will be carried out in the lower half of Form 2087. The following tables will be required :—

Table VI .. Corrections to the temperature of dry or saturated air to give the temperature of half saturated air having the same density ("adjusted" temperature).

Table III .. Temperature weighting factors for S.T. meteor reports.

Enter the forecast temperatures and humidities in the columns provided on the form. For heights below 1,000 ft. they should be obtained by interpolating between the observed surface values and the values forecast for 1,000 ft.

Compute the "adjusted" temperatures in the manner indicated in Table VI.

Enter the "adjusted" temperatures (Table VI) against the corresponding heights, and subtract the corresponding standard temperatures given on the form. Enter the differences together with their appropriate signs. When the "adjusted" temperature is higher than the standard temperature the sign will be positive, and when it is lower the sign will be negative.

Multiply the differences in each layer by the appropriate weighting factors obtained from Table III for the corresponding layers and T.Fs. (A table of products of weighting factors and temperature differences is given in Appendix V.) Enter the products and obtain the algebraic sum of the products for each T.F. Add or subtract the sums to or from 60° F. according as the sign is positive or negative. This gives the B.Ts. and these should be entered on the form in the spaces provided.

For a time of flight of five seconds assume surface temperature when the lapse rate is small; but when convection is strong in the middle of the day the decrease of temperature to a height of about 50 ft. may be as much as 4° or 5° F. and to obtain the ballistic temperature for a time of flight of 5 seconds the surface temperature, after adjustment for humidity, should be decreased by, say, 2° to 4° F. When there is an inversion of temperature near the ground after a clear still night the temperature may increase from 7° to 10° F. at a height of 50 ft. It is dangerous to attempt to follow any general rule in such cases.

§5. FORM OF S.T. METEOR REPORTS

General form.—Meteorological reports supplied to artillery units for use in gunnery against surface targets will be issued in the following form :—

S.T. Meteor XXXXX gggg Bar PPPP fTT vvDDD fTT vvDDD
..... fTT vvDDD g'g'g'g' Date

The letters here used to show the form of the report have the following meanings :—

S.T. Meteor = Meteor report for use in gunnery against surface targets.

XXXXX = Letters or words denoting the station or area covered by the report.

gggg = The mid time (clock) of the four-hourly period covered by the report.

PPPP	= Height of the barometer at M.S.L. in inches, tenths and hundredths (Table X).
ff	= Time of flight in seconds, referring to the data in the group in which it occurs and in the next following group.
TT	= Ballistic temperature in degrees F. (TTT when the B.T. is greater than 99° F.).
vv	= Velocity of the E.C.W. in ft. sec. units (vvv when the E.C.W. exceeds 99 ft. sec.).
DDD	= Direction of the E.C.W. on the scale, 001° to 360° (T.B.).
g'g'g'g'	= Clock time of issue from the Meteorological Office which originated the report.

Example of an S.T. meteor report.—An example of a meteor report for use in gunnery against surface targets is as follows:—

S.T. Meteor B. Corps Area 1400 Bar 2976 0550 45179 1049 48184
2048 51188 3047 57191 4045 65193 5043 73195 6041 81196 7039
89197 8037 102197 1135 15.11.41.

§6. S.T. REPORTS FOR MORTARS, LIVENS PROJECTORS AND MACHINE GUNS

Mortars.—The ranging of individual mortars may differ from the range tables under standard meteorological conditions by as much as 10 per cent. of the range, and the exact range to a target with any given mortar can only be found by actual corrections during firing. When this method of correcting the range is used, correction for wind, temperature and barometer are included. The meteor corrections can however be applied separately when required. Special meteor reports, such as those issued to artillery units, are not necessary for this purpose.

The displacement of a mortar bomb at the point of impact, along or across the line of fire, is given with sufficient accuracy by the formula:—

$$\frac{WT}{6} \text{ yards}$$

in which

W = the mean value up to the vertex of the trajectory of the appropriate component of the wind in ft. sec. units;

T = the time of flight in seconds.

The formula assumes that the displacement is equal to half the run of the wind during the time the bomb is in the air. The vertex height can be obtained from the time of flight with the use of the usual formula given on p. 8 and an observation of the mean wind up to that height, or an estimate of the mean wind based on observations, is all that is required. If it is more convenient, the wind can be obtained from the S.T. meteor report issued to artillery units, by interpolating for the required time of flight. The fact that the E.C.Ws. in the meteor report are weighted is not important.

Temperature and pressure corrections will not normally be necessary unless there is an extremely large variation from average conditions in south-east England. When required, the surface pressure at the battery position and an estimated mean temperature up to the vertex of the trajectory should be given.

Livens projectors.—Livens projectors are similar to mortars, but as they are dug into the ground at the elevation required to give the desired range, it is impossible to alter the elevation to suit the meteorological conditions at the time of firing. If meteor information is required the same information as for mortars should be supplied except that, generally, it will be necessary to obtain a forecast of the mean wind expected at the probable time of firing of the mortars.

Machine guns.—The meteor reports issued to artillery units should be supplied for machine gun fire against surface targets when required.

§7. MISCELLANEOUS MATTERS

Approximate methods of determining E.C.Ws. and B.Ts. for small times of flight.—There may be occasions when a simple approximate method of obtaining E.C.Ws. and B.Ts. will be of value. On such occasions the following rules may be used:—

Equivalent constant wind

For T.F. 5 sec. .. Use surface wind provided it is measured at a height not less than 15 ft.

For T.F. 10 sec. .. Use arithmetic mean of speeds and directions at surface and at 500 ft.

For T.F. 20 sec. .. Use arithmetic means of speeds and directions at surface, 500, 1,000 and 1,500 ft.

If the variation of wind with height is very large vector means should be used instead of arithmetic means.

A lower order of accuracy is obtained if the winds at the surface, 500 ft. and 1,000 ft. are used as E.C.Ws. for 5, 10 and 20 sec. respectively.

Ballistic temperature

For T.F. 5 sec. .. Use surface temperature unless it is more than 5° F. lower than the temperature at 500 ft. On such occasions increase the surface temperature by one third of the difference between surface and 500 ft. temperatures.

For T.F. 10 sec. .. Use temperatures at 500 ft.

For T.F. 20 sec. .. Use temperatures at 1,000 ft.

Difference of height of battery and target.—The effect of the wind and density in any sub-layer upon the form of a trajectory is made up of two parts, corresponding to the ascending and descending branches of the trajectory, and the effect is greater in the ascending than in the descending portion. In the lowest sub-layers the effect of the descending branch is negligible, and this point is of importance in the field.

In hilly country the target may be at a different height from the battery. There are three cases:—

(a) If the difference in height between battery and target is less than half the height of the vertex of the trajectory above the battery, the meteorological effect of the shortening or prolongation of the trajectory is negligible. In compiling a meteor report for such a case the meteorologist should neglect the fact that the target is not at battery level. (In evaluating the range a correction is made by the gunner taking into account the angle of descent of the projectile.)

(b) If the difference in level between the gun and target exceeds half the vertex height of the trajectory above the gun then the mean wind and temperature in either the layer between the vertex and the gun or the layer between the vertex and the target, whichever layer is the greater, should be supplied.

(c) When the target is at or near the vertex of the trajectory, the E.C.Ws. and B.Ts. given in A. A. Meteor Reports (Part II) are applicable.

Meteor reports for batteries substantially above sea level.—If the battery is substantially above sea level an appreciable part of the trajectory will be in a layer of air which is not entered by the trajectory of a projectile fired by a battery at sea level. The wind and temperature conditions obtaining in this layer have no influence on the meteor report computed for the battery at the lower level but clearly will affect the path followed by the projectile from the higher battery. It follows therefore that there is no method of adjusting a meteor report computed for a battery at sea level to make it appropriate to a battery at a higher level unless the wind and temperature distributions in the higher layer are known.

But, when it is known that a battery is substantially above sea level, all heights used in the computation of the meteor report should be treated as heights above battery level, except that heights above sea level will be used when adjusting temperatures with the aid of Table VI. Thus, if a battery is 6,000 ft. above sea level, the meteor report for 30 sec. T.F. should be based upon winds and temperatures at 7,000 and 9,000 ft. above sea level (in the vicinity of the battery). The standard temperatures for these heights (from Table VII) are 58.3° F. and 54.5° F. and the corrections to the forecast temperatures to give the adjusted temperatures are obtained from Table VI from the lines for 7,000 and 9,000 ft. It should be noted, however, that the barometric pressure (PPPP) supplied in the early part of the meteor report should still be pressure at M.S.L. since the battery commander himself corrects this for height of battery.

In the preceding paragraphs the phrase "substantially above sea level" has been used. It is clear that the magnitude of the error involved in using a meteor report computed for a battery assumed to be at sea level for a gun firing from a greater height will depend upon various factors such as the configuration of the land, the vertex height above battery position, etc. Each case should be treated on its merits, but as a rough working rule it may be assumed that this correction becomes significant when the height of the battery above M.S.L. exceeds ten per cent. of the vertex height above the battery. It is assumed that no marked wind discontinuities are involved. If such discontinuities do occur in the layers affected no approximate rule can be given.

Vertical air currents.—Vertical currents, when present, may produce very considerable effects on range. It is quite possible to calculate weighting factors to give the effect of any combination of upward and downward currents. In practice, vertical currents are localised and vary greatly in magnitude, and with time and place. It is therefore impossible to ensure that any measurements of vertical currents which can be made with pilot balloons will give the distribution of vertical currents in the trajectory of any shell. Weighting factors for such currents and the corresponding corrections to range are not therefore evaluated. When strong vertical currents are observed, or when the official forecast, or the appearance of the sky or the lapse of temperature indicate the presence of strong vertical currents, the usual procedure is to report it to the headquarters of the artillery unit or formation, particularly in calibration firings. Under such conditions substantial errors which cannot be evaluated are likely to occur, and it should be noted that the relative effect of vertical winds is greatest for the smaller times of flight.

Corrections for meteor in mountainous country.—In mountainous country the wind may vary so much over short distances that it is no longer justifiable to assume that pilot-balloon observations give any useful indication of the wind operating on a shell throughout its trajectory. In these circumstances the batteries concerned should correct the fall of the rounds by observation or employ the method of air burst ranging to determine the correction of the moment.

Cloud, rain and fog.—The effect of cloud, rain and fog and other forms of precipitation has not been ascertained with any accuracy, and until this is known, it is not advisable that a meteorologist should endeavour to allow for it in the meteorological report, as, for instance, by a modification of the E.C.Ws., the B.Ts. or the pressure.

PART II

ANTI-AIRCRAFT METEOR REPORTS

§8. INTRODUCTION

Meteor reports for use in anti-aircraft gunnery are prepared in the same way as reports for gunnery against surface targets, except that different weighting factors are used and the E.C.Ws. and B.Ts. are prepared for layers extending up to various heights which are specified in thousands of feet instead of T.Fs. They apply only to targets engaged at the top of the layer and on the ascending branch of the trajectory of the shell.

The layers for which E.C.Ws. and B.Ts. are supplied are as follows :—

0- 4,000 ft.	0-24,000 ft.
0- 8,000 ft.	0-28,000 ft.
0-12,000 ft.	0-32,000 ft.
0-16,000 ft.	0-36,000 ft.
0-20,000 ft.	0-40,000 ft.

and the E.C.Ws. and B.Ts. for each layer are calculated from the mean winds, temperatures and humidities in the following sub-layers :—

0- 2,000 ft.	14,000-16,000 ft.
2,000- 4,000 ft.	16,000-20,000 ft.
4,000- 6,000 ft.	20,000-24,000 ft.
6,000- 8,000 ft.	24,000-28,000 ft.
8,000-10,000 ft.	28,000-32,000 ft.
10,000-12,000 ft.	32,000-36,000 ft.
12,000-14,000 ft.	36,000-40,000 ft.

The effect of wind and density variations is to displace the point of burst vertically as well as horizontally, and there are appropriate weighting factors for individual trajectories which will give the displacement in all three directions in space, for a given line of fire relative to the wind direction. These are used only in experimental firings. For operational purposes, mean weighting factors are used which are prepared from the weighting factors of the trajectories of all guns. These are given in Tables IV and V, weighting factors for heights up to 40,000 ft. being included in case meteor reports to these greater heights are ever required. In obtaining the means the weighting factors for vertical displacements are excluded. The line wind and cross wind weighting factors are included together in the mean wind weighting factors, and the E.C.Ws. obtained with the mean weighting factors can be resolved along and across the line of fire.

It will be seen from Tables IV and V that the effects of wind and temperature variation on the position of the point of burst are greater in the lower portion of the trajectories.

Variations of the relative humidity from 50 per cent. are allowed for as in the preparation of S.T. meteor reports, by using "adjusted" temperatures (see Table VI), and the pressure at M.S.L. is included for the correction of all trajectories for density variations due to variations of pressure.

For some types of gun the A.A. gunner also requires to know the true wind at definite heights as well as the weighted mean winds up to certain heights. The heights for which true winds are required at present are 10,000, 15,000 and 20,000 ft.

§9. OBSERVATIONS AND FORECASTS

As in the preparation of surface target meteor reports, values for winds, temperatures and humidities at various heights are required but measurements of surface winds are not needed. As in the preparation of surface target meteors the ideal procedure would be to measure the various quantities from a site near the gun at the time of firing, but in practice it will usually be necessary and desirable to use values forecast for the period and locality concerned.

§10. COMPUTATION OF A.A. METEOR REPORTS

Equivalent constant winds.—The computation of the E.C.W. for each trajectory is carried out in the sections provided in the upper half of Form 2079 (see Appendix II). The following tables will be required.

Table IA .. Resultants and components in the same units ;

Table IV .. Wind weighting factors for A.A. meteor reports ;

Table IX .. Conversion of m.p.h. to ft. sec. units.

Enter the forecast value of the wind in ft. sec. units and degrees from true north on Form 2079. Obtain the components of the forecast winds by the use of Table IA and enter them in the appropriate spaces. Multiply the mean components in each layer by the appropriate weighting factors obtained from Table IV. (A table of products of weighting factors and wind components is given in Appendix VI.) Note that the same weighting factor is used for both components in a given layer. Enter the products, together with their positive or negative signs in the columns headed with the respective trajectory heights. Obtain the algebraic sums of the products and enter them in the spaces provided. The sums are the components of the E.C.Ws. in ft. sec. units. Obtain the velocity and direction with the use of Table IA and enter them on the form.

If the results of a suitable pilot-balloon ascent are available the components at the various heights can be obtained as in the case of S.T. meteors.

Ballistic temperatures.—The computation of the B.Ts. for A.A. meteor reports will be carried out in the lower half of Form 2079. The following tables will be required :—

Table VI .. Corrections to the temperature of dry or saturated air to give the temperature of half saturated air having the same density ("adjusted" temperatures).

Table V .. Temperature weighting factors for A.A. meteor reports.

The procedure for the calculation of B.Ts. for A.A. meteor reports is similar to the procedure for obtaining the B.Ts. in S.T. meteor reports and the instructions given on p. 11, should be followed except that the weighting factors given in Table V will be used. (A table of products of weighting factors and temperature differences is given in Appendix VII.)

§11. THE FORM OF A.A. METEOR REPORTS

General Form.—Meteor reports supplied to artillery units for use in A.A. gunnery will be issued in the following form :—

A.A. Meteor XXXXX gggg Bar PPPP hhTT vvDDD
 hhTT vvDDD hhTT vvDDD etc. hhTT vvDDD
 True h'h' v'v'v'D'D'D' h'h' v'v'v'D'D'D' h'h' v'v'v'D'D'D'
 g'g'g'g' Date

When A.A. meteor reports have to be communicated from the Meteorological Office to the Battery by telegram the three pairs of groups of the form h'h' v'v'v'D'D'D' following the word "True" may be rearranged in the form h'h' v'v'v' D'D'D'.

The letters here used to show the form of the report have the following meanings :—

A.A. Meteor = Meteor report for use in A.A. gunnery ;

hh = Height of the trajectory to the point of burst in thousands of feet. The height refers to the data given in the group in which it occurs and in the next following group ;

True Indicates that groups following refer to true winds ;

h'h' = Height in thousands of feet ;

v'v'v' = Velocity of wind in ft. sec. units at height indicated in preceding group ;

D'D'D' = Direction in degrees T.B. from which wind blows at height indicated in preceding group.

The remaining letters have the same meanings as in the form of the S.T. meteor report.

Example of an A.A. meteor report :—

A.A. Meteor B Div. Area. 0200 Bar 2976 0261 42211 0459 43223
 0857 47227 1255 51230 1634 58233 2053 65236 2452 20240 2851 91235
 3250 101249 True 10 055231 15 070235 20 103241 2330 1.11.41.

PART III

METEOR REPORTS FOR CALIBRATION BY THE FALL OF SHOT

§12. THE OBJECT OF CALIBRATION FIRINGS

The range obtained with a gun at a given elevation and charge decreases as the gun wears. The ranges given in the range tables refer to the performance of the gun when new or nearly new, and in order to determine the corrections to the tables in the use of a worn gun, an absolute calibration is carried out. The process includes measurements of the ranges and deviations realised, and the measurements obtained require to be corrected to allow for the effect of wind and density variations throughout the trajectory at the time of firing.

The corrections are applied, as in operational firings, with the use of E.C.Ws., B.Ts. and pressures at M.S.L., but in calibration firings they are based on data obtained as near as possible to the gun position during the actual period of the shoot.

The mean weighting factors used for the calculation of E.C.Ws. and B.Ts. for operational meteors are not suitable for calibration purposes. The weighting factors required are those applicable to the particular gun and shell used, and the quadrant elevation of the gun and separate wind weighting factors are required for the line wind and cross wind components. These will be obtained from the appropriate meteorological service headquarters.

It is not necessary to evaluate the E.T. for calibration firings. The fall of the rounds in a calibration shoot are corrected for meteor variations from the data given in the range tables. It is assumed in the compilation of the range tables that the E.T. will always be the same as the B.T. and the corrections for elasticity variations are included in the temperature corrections. The exact value of the elasticity correction corresponding to the true E.T. cannot therefore be calculated.

§13. GUNNERY DETAILS REQUIRED TO OBTAIN CALIBRATION WEIGHTING FACTORS

When a calibration shoot is notified, the following information will be obtained from the battery commander :—

- (a) Name of the equipment.
- (b) Calibre of the gun.
- (c) Design of the shell (standard, streamlined or truncated).
- (d) Calibres-radius head (C.R.H.) of the shell.
- (e) Weight of the shell.
- (f) Fuze.
- (g) The expected muzzle velocity.
- (h) Number of charge.
- (i) Quadrant elevation.
- (j) Expected time of flight.

The details of items (a) to (j) will be passed to the appropriate meteorological service headquarters by the quickest possible route, with a request for the appropriate weighting factors. Headquarters will then forward the weighting factors in the following form :—

Calibration Weighting Factors 6-in. Mk. VII Gun. Firing Details as in.....										
% Height	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Line Wind										
Cross Wind										
Temperature										

§14. METEOROLOGICAL OBSERVATIONS DURING CALIBRATION FIRINGS

Calculation of the vertex height.—Calculate the vertex height of the trajectory from the following formula :—

$$H = KT^2$$

in which H = Vertex height in feet ;

T = Expected time of flight in seconds ;

K = A constant (Kappa).

The numerical value of K will be obtained from Table VIII, which gives values of K appropriate to the different classes of equipment. The value of K should be entered in the space provided on Form 2073.

Upper wind observations.—Arrangements should be made to obtain wind measurements up to the vertex of the trajectory as near as possible to the firing point during the actual period of the shoot. The winds should be obtained by one of the following methods or partly by one and partly by another :—

- (a) 2-theodolite method.
- (b) Theodolite observations on A.A. shell bursts or smoke puffs from an aeroplane.
- (c) Tail method.
- (d) Single theodolite method without tail.
- (e) Estimated winds.

The methods mentioned are given in order of preference.

Instructions for the use of the 2-theodolite method will be found in the Computer's Handbook. The single theodolite and tail methods are described in M.O.396, "The measurement of upper winds by means of pilot balloons".

When the vertex height is less than 2,000 ft. balloons with a nominal rate of ascent of 400 ft. min. should be used. Half-minute readings of pilot-balloons can also be arranged, for shoots in which the vertex is less than about 1,000 ft., so as to obtain the winds in 200-ft. layers.

Form 2081 will be used for the computation of single theodolite observations with or without tail and Form 3611 will be used for computing 2-theodolite observations.

The time interval between the start of successive pilot-balloon ascents during the shoot will normally be about 40 minutes, but synchronisation with the rounds should be arranged if circumstances permit and if it does not lead to excessive expenditure of balloons. Synchronisation is most useful when the vertex is below a few thousand feet.

Observations on shell bursts or smoke puffs from an aeroplane will be used, when it is anticipated that detached clouds will prevent pilot-balloon observations up to the vertex, if suitable arrangements can be made prior to the shoot. The height intervals at which the bursts are fired will be arranged according to the height of the vertex. The intervals should not normally be less than 2,000 ft. for low trajectories or more than 5,000 ft. for high trajectories.

One series immediately prior to the shoot will be sufficient, if used in conjunction with pilot-balloon observations during the shoot up to the cloud base. If a shoot is continued for several hours, or resumed after several hours, a repeat series of shell-burst observations is desirable.

Observations with one or two theodolites on shell bursts or smoke puffs can be carried out in the same way as observations on pilot-balloons and they can be computed on the pilot-balloon forms. The azimuth and elevation of a puff is observed at the beginning and end of a one-minute interval. The observations should be carried out without loss of time before the smoke disperses. Computation by the two-theodolite method will give the actual

height of the puff as well as the wind velocity and direction at that height, but in computation by the single theodolite method, the pre-arranged height must be assumed.

The battery commander should be notified prior to the shoot if the wind at any height up to the vertex is expected to exceed 60 ft. sec. He should also be notified during the shoot if the wind increases above 60 ft. sec. while firing is in progress.

A calibration shoot should not be carried out unless wind measurements up to the vertex height can be obtained. If, however, it is not possible to postpone the shoot until such conditions occur, wind observations should be carried out up to the base of the clouds and estimated winds should be obtained for the remainder of the trajectory above the clouds. Occasions when strong convection currents over any considerable height are likely to occur should also be avoided for calibration shoots if possible. In mountainous country large vertical components of the wind are liable to be encountered, and it is undesirable to calibrate guns in such conditions.

Arrangements should be made for the battery to notify the meteorologist immediately prior to the shoot when the battery will open fire, and to pass the "Cease Fire" immediately after the completion of the shoot.

Surface observations.—Measurements of the surface wind, temperature, humidity and pressure will be carried out at the time of each pilot-balloon ascent in accordance with the instructions given on p. 9. Surface winds from a recorder should not be used unless the recorder is reasonably near the battery position.

Estimated winds, temperatures and humidities in the upper air.—When a calibration shoot is notified, the nearest meteorological office supplying upper-air data for operational meteor reports will be warned that upper-air data for a calibration shoot will be required and they will be given the date, place and approximate time of the shoot. At the conclusion of the shoot the time of the shoot will be confirmed and a request made for estimated winds, temperatures and humidities at convenient heights up to the vertex of the trajectory. The estimates will be issued in the same way as the usual issue of upper-air data for operational meteor reports as given on p. 9, but the heights hh will be adjusted as requisite. The office will be informed of the height to which winds have been obtained by measurements, and the wind groups in the message below that height will be given as XXXXX. The calibration meteor report will not normally be required immediately after the shoot and it may be possible for radio or aeroplane ascents carried out before and after the shoot to be utilised in the estimation of the upper-air data required.

§15. COMPUTATIONS FOR CALIBRATION METEOR REPORTS

Equivalent constant winds.—The computations for calibration meteor reports will be carried out on Form 2073 (see Appendix III) and a separate form will be used for each ascent. Two E.C.Ws. will be computed for each ascent viz.: the equivalent constant line wind (E.C.L.W.) and the equivalent constant cross wind (E.C.C.W.). They should be computed in the spaces provided in the top half of Form 2073, and the weighting factors used should be obtained from the data specially supplied from H.Q. for the shoot. The following table will be required:—

Table I ... Resultants in feet per second and degrees and components in hundreds of feet per minute.

Divide the height of the trajectory into ten layers and enter the mid heights of the layers on the form. Obtain the wind components V_E and V_N , corresponding to the mid heights of the layers by interpolating between the observed components at the mid heights of the observed one-minute (or half-minute) layers, or between the components of the estimated

TABLE I—RESULTANTS IN FEET PER SECOND AND DEGREES AND COMPONENTS IN HUNDREDS OF FEET PER MINUTE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	45	27	18	14	11	9	8	7	6	5	5	4	4	4	4	4	3	3	3	3	3	3	2	2	2	2	2	2	2	2
2	45	34	27	22	19	16	14	13	11	10	9	9	8	8	7	7	6	6	6	5	5	5	5	5	4	4	4	4	4	4
3	45	37	31	27	23	21	18	17	15	14	13	12	11	11	10	9	9	8	8	7	7	7	7	6	6	6	6	5	5	5
4	45	39	34	30	27	24	22	20	19	17	16	15	14	13	12	11	10	10	9	9	8	8	8	7	7	7	6	6	6	6
5	45	41	37	34	31	28	25	23	21	20	19	18	17	16	15	14	13	12	11	10	10	9	9	8	8	8	7	7	7	7
6	45	43	41	38	35	32	30	28	26	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	10	9	9	8	8	8
7	45	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	10
8	45	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
9	45	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11
10	45	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12
11	45	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13
12	45	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14
13	45	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15
14	45	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17	16
15	45	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18	17
16	45	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19	18
17	45	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20	19
18	45	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21	20
19	45	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22	21
20	45	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23	22
21	45	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24	23
22	45	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25	24
23	45	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26	25
24	45	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27	26
25	45	81	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28	27
26	45	83	81	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	28
27	45	85	83	81	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29
28	45	87	85	83	81	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31
29	45	89	87	85	83	81	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33
30	45	91	89	87	85	83	81	79	77	75	73	71	69	67	65	63	61	59	57	55	53	51	49	47	45	43	41	39	37	35

NOTE 1
Angles in Italics

RESULTANTS IN CLARENDON

NOTE 2
For components larger than those shown halve both components; use these halved values in the table and double the resultant speed, but not the angle.

NOTE 3
If A is the angle given by the table, following are rules for obtaining actual wind direction in degrees measured from North:—

$$V_t - V_N - \begin{cases} V_t < V_N A \\ V_t > V_N 90-A \end{cases} \quad V_t + V_N + \begin{cases} V_t < V_N 180+A \\ V_t > V_N 270-A \end{cases}$$

$$V_t - V_N + \begin{cases} V_t > V_N 90+A \\ V_t < V_N 180-A \end{cases} \quad V_t + V_N - \begin{cases} V_t > V_N 270+A \\ V_t < V_N 360-A \end{cases}$$

NOTE 4
To obtain components V_t and V_c (in 100 ft. min. units) along and across the line of fire, subtract the line of fire from the wind direction and add 360° if the difference is negative. If R is the angle obtained and if B is an angle less than 45°, the following gives V_t and V_c and their appropriate signs:—

$$R = B \quad \begin{cases} V_t > V_c \\ V_t < V_c \end{cases} \quad \begin{cases} V_t - V_c \\ V_t + V_c \end{cases} \quad R = 180+B \quad \begin{cases} V_t > V_c \\ V_t < V_c \end{cases} \quad \begin{cases} V_t + V_c \\ V_t - V_c \end{cases}$$

$$R = 90+B \quad \begin{cases} V_t < V_c \\ V_t > V_c \end{cases} \quad \begin{cases} V_t + V_c \\ V_t - V_c \end{cases} \quad R = 270+B \quad \begin{cases} V_t < V_c \\ V_t > V_c \end{cases} \quad \begin{cases} V_t - V_c \\ V_t + V_c \end{cases}$$

$$R = 180-B \quad \begin{cases} V_t > V_c \\ V_t < V_c \end{cases} \quad \begin{cases} V_t + V_c \\ V_t - V_c \end{cases} \quad R = 360-B \quad \begin{cases} V_t > V_c \\ V_t < V_c \end{cases} \quad \begin{cases} V_t - V_c \\ V_t + V_c \end{cases}$$

Divide 100 ft. min. components by 0.6 to obtain ft. sec.

winds at the heights for which estimated winds have been obtained. When the 10 per cent. layers are about the same size as the observed layers, no subdivision of the 10 per cent. layers is required to obtain a mean for the layer. When they are more than twice the size of the observed layers the 10 per cent. layers should be divided into equal sub-layers which are as nearly as possible equal in thickness to the observed layers, the wind components corresponding to the mid points of the sub-layers should be obtained by interpolation between the mid points of the observed layers, and finally the mean value of the components appropriate to the sub-layers should be used as components for the 10 per cent. layer. If the observed layers are large compared with the 10 per cent. layers, two or more of the 10 per cent. layers should be combined by adding the weighting factors.

In any 10 per cent. layer partly covered by the pilot-balloon observations, interpolate for the mid height of the layer only using the forecast winds if the observed winds do not cover the mid height of the layers.

Enter the mean components for the 10 per cent. layers on the form and obtain the resultants in ft. sec. units and degrees (T.B.), using Table I.

Subtract the bearing of the line of fire from the direction of the resultant wind and add 360 degrees if the difference is negative. The result gives the direction of the wind relative to the line of fire. Enter the relative wind direction in the column provided on the form. The velocity of the relative wind is the same as the actual wind velocity.

Resolve the relative wind into components, V_L and V_C , in ft. sec. units, along and across the line of fire. The components should be obtained with the pilot-balloon slide rule. V_L and V_C may be distinguished in the manner described in M.O. 396, p. 23, for distinguishing between D_N and D_E in pilot-balloon computation. It should be noted that the given line of fire is the bearing of the target from the gun and the sign of the component of the wind along the line of fire should be given as positive if it is a following wind blowing from the gun to the target. It should be given as negative if it is a head wind blowing from the target to the gun. The component of the wind across the line of fire is positive if it is blowing from left to right, and negative if it is blowing from right to left, looking towards the target from the gun.

It will be found convenient at first, to draw a diagram showing the direction of the wind relative to two axes along and across the line of fire. The components obtained and their signs can be verified with the use of Table I and the rules given in Note 4 at the bottom of Table I.

Enter the 10 per cent. line wind and cross wind weighting factors and multiply them by the line wind and cross wind components. Obtain the respective algebraic sums of the products and divide the sums by 100 to obtain the E.C.L.W. and the E.C.C.W.

Ballistic temperatures.—The computation of the B.T. for the calibration report will be carried out in the lower half of Form 2073. The following tables will be required:—

Table VI .. Corrections to the temperature of dry or saturated air to give the temperature of half-saturated air having the same density ("adjusted" temperature).

Table VII .. Ballistic standard temperatures.

Enter the mid heights of the 10 per cent. layers and obtain the corresponding temperatures and humidities by interpolating from the estimated temperatures and humidities supplied for the shoot. Calculate the "adjusted" temperatures with the use of Table VI and enter them in the appropriate column on the form. Obtain the standard temperatures at the mid heights of the layers from Table VII and proceed with the calculation of the B.T. in the manner described on p. 11.

§16. FORM OF THE CALIBRATION METEOR REPORT

A calibration meteor report should be prepared in the following manner and passed to the battery commander:—

9.2 in. How. Calibration Shoot.

July 3, 1941.

Meteorological Report

Q.E. = $40^{\circ} 11'$ Time of Flight = 40.08 sec.
 Expected M.V. = 1475 ft. sec. Assumed Vertex Height = 9470 ft.
 Bearing of Line of Fire = N.67°E.

Times (Clock Time)	Line wind	Cross wind	Ballistic temperature	Barometer M.S.L.
hrs.	ft. sec.	ft. sec.	° F.	in. Hg
1020	18 (Following)	10 (L to R)	68.7	30.07
1040	12 "	5 (L to R)	69.2	30.09
1115	5 (Head)	3 (R to L)	69.8	30.13

TABLE II—WIND WEIGHTING FACTORS FOR S.T. METEOR REPORTS

Layer 1,000's of feet	T.F. 10 sec.	T.F. 20 sec.	T.F. 30 sec.	T.F. 40 sec.	T.F. 50 sec.	T.F. 60 sec.	Layer 1,000's of feet	T.F. 70 sec.	T.F. 80 sec.
Surface	0.25	—	—	—	—	—	—	—	—
0-0.5	0.5	0.19	—	—	—	—	—	—	—
0.5-1.0	0.25	0.23	—	—	—	—	—	—	—
1.0-1.5	—	0.58	—	—	—	—	—	—	—
0-2	—	—	0.47	0.21	0.13	0.09	0-4	0.16	0.11
2-4	—	—	0.53	0.25	0.15	0.10	4-8	0.16	0.11
4-6	—	—	—	0.54	0.17	0.11	8-12	0.16	0.12
6-8	—	—	—	—	0.19	0.11	12-16	0.17	0.13
8-10	—	—	—	—	0.36	0.13	16-20	0.35	0.14
10-12	—	—	—	—	—	0.15	20-24	—	0.20
12-14	—	—	—	—	—	0.31	24-28	—	0.19

TABLE III—TEMPERATURE WEIGHTING FACTORS FOR S.T. METEOR REPORTS

Mid Ht. of Layer, ft.	T.F. 10 sec.	T.F. 20 sec.	T.F. 30 sec.	T.F. 40 sec.	T.F. 50 sec.	T.F. 60 sec.	T.F. 70 sec.	T.F. 80 sec.
100	0.44	—	—	—	—	—	—	—
300	0.55	—	—	—	—	—	—	—
250	—	0.26	—	—	—	—	—	—
750	—	0.28	—	—	—	—	—	—
1,250	—	0.44	—	—	—	—	—	—
1,000	—	—	0.45	0.22	0.11	0.05	—	—
3,000	—	—	0.49	0.24	0.13	0.07	—	—
5,000	—	—	—	0.43	0.14	0.08	—	—
7,000	—	—	—	—	0.16	0.09	—	—
9,000	—	—	—	—	0.28	0.10	—	—
11,000	—	—	—	—	—	0.11	—	—
13,000	—	—	—	—	—	0.27	—	—
2,000	—	—	—	—	—	—	0.08	0.06
6,000	—	—	—	—	—	—	0.09	0.07
10,000	—	—	—	—	—	—	0.10	0.07
14,000	—	—	—	—	—	—	0.13	0.08
18,000	—	—	—	—	—	—	0.29	0.08
22,000	—	—	—	—	—	—	—	0.11
26,000	—	—	—	—	—	—	—	0.11

TABLE IV—WIND WEIGHTING FACTORS FOR A.A. METEOR REPORTS

Layer 1,000's of feet	4,000 ft.	8,000 ft.	12,000 ft.	16,000 ft.	20,000 ft.	24,000 ft.	28,000 ft.	32,000 ft.	36,000 ft.	40,000 ft.
0- 2	.71	.33	.25	.18	.16	.13	.11	.10	.10	.09
2- 4	.29	.32	.24	.19	.16	.13	.10	.10	.09	.08
4- 6	—	.26	.22	.18	.15	.13	.10	.10	.09	.08
6- 8	—	.09	.16	.17	.14	.12	.10	.10	.09	.08
8-10	—	—	.10	.13	.12	.11	.10	.10	.09	.08
10-12	—	—	.03	.08	.10	.10	.09	.09	.08	.07
12-14	—	—	—	.05	.07	.08	.08	.09	.07	.07
14-16	—	—	—	.02	.06	.07	.08	.08	.07	.07
16-20	—	—	—	—	.04	.10	.12	.13	.12	.12
20-24	—	—	—	—	—	.03	.09	.07	.10	.11
24-28	—	—	—	—	—	—	.03	.03	.06	.08
28-32	—	—	—	—	—	—	—	.01	.03	.04
32-36	—	—	—	—	—	—	—	—	.01	.02
36-40	—	—	—	—	—	—	—	—	—	.01

TABLE V—TEMPERATURE WEIGHTING FACTORS FOR A.A. METEOR REPORTS

Mean Height of Layer, ft.	4,000 ft.	8,000 ft.	12,000 ft.	16,000 ft.	20,000 ft.	24,000 ft.	28,000 ft.	32,000 ft.	36,000 ft.	40,000 ft.
1,000	.71	.37	.25	.16	.12	.09	.07	.07	.06	.05
3,000	.26	.30	.21	.16	.12	.09	.07	.06	.05	.04
5,000	—	.20	.17	.15	.12	.09	.07	.06	.06	.04
7,000	—	.05	.12	.13	.11	.08	.06	.06	.06	.04
9,000	—	—	.08	.10	.09	.08	.06	.06	.05	.04
11,000	—	—	.03	.07	.08	.07	.06	.06	.04	.04
13,000	—	—	—	.05	.06	.06	.06	.06	.05	.04
15,000	—	—	—	.01	.05	.06	.05	.05	.05	.04
18,000	—	—	—	—	.05	.08	.09	.09	.08	.08
22,000	—	—	—	—	—	.03	.07	.05	.06	.07
26,000	—	—	—	—	—	—	.03	.03	.04	.05
30,000	—	—	—	—	—	—	—	.02	.02	.03
34,000	—	—	—	—	—	—	—	—	.02	.02
38,000	—	—	—	—	—	—	—	—	—	.01

TABLE VI—CORRECTIONS TO THE TEMPERATURE OF DRY OR SATURATED AIR TO GIVE THE TEMPERATURE OF HALF-SATURATED AIR HAVING THE SAME DENSITY (ADJUSTED TEMPERATURE)

Add to the observed temperature in the case of saturated air. Subtract in the case of dry air.

Height (ft.)	Temperature (°F.)															
	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0
0	18.2	14.9	12.1	9.6	7.5	5.7	4.3	3.2	2.3	1.6	1.1	0.8	0.5	0.3	0.2	0.1
1,000		15.3	12.4	9.9	7.7	5.9	4.4	3.3	2.4	1.7	1.2	0.8	0.5	0.3	0.2	0.1
3,000				10.5	8.7	6.7	5.0	3.7	2.5	1.8	1.2	0.9	0.6	0.4	0.2	0.1
5,000					9.2	7.1	5.4	4.0	2.7	2.1	1.4	1.0	0.6	0.4	0.2	0.1
7,000						7.5	5.7	4.2	3.1	2.2	1.5	1.0	0.7	0.4	0.3	0.2
9,000						8.0	6.1	4.5	3.3	2.4	1.6	1.1	0.7	0.5	0.3	0.2
11,000							6.5	4.8	3.5	2.5	1.8	1.2	0.8	0.5	0.3	0.2
13,000								5.2	3.8	2.7	1.9	1.3	0.9	0.5	0.3	0.2
15,000									4.2	3.0	2.1	1.5	1.0	0.6	0.4	0.2
18,000										3.5	2.4	1.7	1.1	0.7	0.4	0.2
22,000											2.8	2.0	1.3	0.8	0.5	0.3
26,000												2.3	1.5	1.0	0.6	0.3
30,000													1.8	1.1	0.7	0.4
34,000														1.4	0.8	0.5
38,000																

For intermediate humidities proportional corrections should be taken, e.g. for a relative humidity of 80 per cent. add three-fifths of the above corrections.

TABLE VII—UPPER AIR TEMPERATURES IN THE STANDARD BALLISTIC ATMOSPHERE

Height	Temperature	Height	Temperature	Height	Temperature
ft.	°F.	ft.	°F.	ft.	°F.
0	60.0	15,000	25.7	30,000	-30.4
1,000	58.2	16,000	22.8	31,000	-35.2
2,000	56.3	17,000	19.8	32,000	-40.2
3,000	54.4	18,000	16.6	33,000	-45.4
4,000	52.4	19,000	13.4	34,000	-50.7
5,000	50.4	20,000	10.1	35,000	-56.2
6,000	48.2	21,000	6.6	Stratosphere temperature	-56.2
7,000	46.1	22,000	3.0		
8,000	43.8	23,000	-0.7		
9,000	41.5	24,000	-4.5		
10,000	39.0	25,000	-8.5		
11,000	36.6	26,000	-12.6		
12,000	34.0	27,000	-16.8		
13,000	31.3	28,000	-21.2		
14,000	28.6	29,000	-25.7		

TABLE VIII—VALUES OF *K* (KAPPA) for Calibration Firings

Equipment	<i>K</i>
All howitzers	4.05
14-inch, 16-inch guns	4.05
12-inch gun, reduced charge	4.10
12-inch gun, full charge	4.15
13-pr., 18-pr., and 25-pr. guns	4.15
5.5-inch gun—howitzer	4.15
9.2-inch gun, reduced charge	4.15
9.2-inch gun, full charge	4.20
60-pr. 4.5-inch and 4.7-inch guns	4.20
6-inch gun, reduced charge	4.25
6-inch gun, full charge	4.30

TABLE IX—CONVERSION OF M.P.H. TO FT./SEC.

1 m.p.h. = 1.46 ft./sec.

M.P.H.	0	1	2	3	4	5	6	7	8	9
	ft./sec.									
0	0	1.5	2.9	4.4	5.9	7.3	8.8	10.3	11.7	13.2
10	14.7	16.1	17.6	19.1	20.5	22.0	23.5	24.9	26.4	27.9
20	29.3	30.8	32.3	33.7	35.2	36.7	38.1	39.6	41.1	42.5
30	44.0	45.5	46.9	48.4	49.9	51.3	52.8	54.3	55.7	57.2
40	58.7	60.1	61.6	63.1	64.5	66.0	67.5	68.9	70.4	71.9
50	73.3	74.8	76.3	77.7	79.2	80.7	82.1	83.6	85.1	86.5
60	88.0	89.5	90.9	92.4	93.9	95.3	96.8	98.3	99.7	101.2
70	102.7	104.1	105.6	107.1	108.5	110.0	111.5	112.9	114.4	115.9
80	117.3	118.8	120.3	121.7	123.2	124.7	126.1	127.6	129.1	130.5
90	132.0	133.5	134.9	136.4	137.9	139.3	140.8	142.3	143.7	145.2
100	146.7	148.1	149.6	151.1	152.5	154.0	155.5	156.9	158.4	159.9

M.P.H.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
ft./sec.	0	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3

To convert M.P.H. given to the nearest tenth, convert the whole number, then convert the decimal by means of the lower table, and add the results.

TABLE X—CONVERSION OF MILLIBARS TO INCHES OF MERCURY AT 32°F. IN LAT. 45°
1000 mb. = 29.5306 in. Hg

MB.	0	1	2	3	4	5	6	7	8	9
	IN., Hg									
700	20.67	20.70	20.73	20.76	20.79	20.82	20.85	20.88	20.91	20.94
710	20.97	21.00	21.03	21.06	21.08	21.11	21.14	21.17	21.20	21.23
720	21.26	21.29	21.32	21.35	21.38	21.41	21.44	21.47	21.50	21.53
730	21.56	21.59	21.62	21.65	21.68	21.70	21.73	21.76	21.79	21.82
740	21.85	21.88	21.91	21.94	21.97	22.00	22.03	22.06	22.09	22.12
750	22.15	22.18	22.21	22.24	22.27	22.30	22.33	22.35	22.38	22.41
760	22.44	22.47	22.50	22.53	22.56	22.59	22.62	22.65	22.68	22.71
770	22.74	22.77	22.80	22.83	22.86	22.89	22.92	22.95	22.97	23.00
780	23.03	23.06	23.09	23.12	23.15	23.18	23.21	23.24	23.27	23.30
790	23.33	23.36	23.39	23.42	23.45	23.48	23.51	23.54	23.57	23.59
800	23.62	23.65	23.68	23.71	23.74	23.77	23.80	23.83	23.86	23.89
810	23.92	23.95	23.98	24.01	24.04	24.07	24.10	24.13	24.16	24.19
820	24.22	24.24	24.27	24.30	24.33	24.36	24.39	24.42	24.45	24.48
830	24.51	24.54	24.57	24.60	24.63	24.66	24.69	24.72	24.75	24.78
840	24.81	24.84	24.86	24.89	24.92	24.95	24.98	25.01	25.04	25.07
850	25.10	25.13	25.16	25.19	25.22	25.25	25.28	25.31	25.34	25.37
860	25.40	25.43	25.46	25.48	25.51	25.54	25.57	25.60	25.63	25.66
870	25.69	25.72	25.75	25.78	25.81	25.84	25.87	25.90	25.93	25.96
880	25.99	26.02	26.05	26.08	26.11	26.13	26.16	26.19	26.22	26.25
890	26.28	26.31	26.34	26.37	26.40	26.43	26.46	26.49	26.52	26.55
900	26.58	26.61	26.64	26.67	26.70	26.73	26.75	26.78	26.81	26.84
910	26.87	26.90	26.93	26.96	26.99	27.02	27.05	27.08	27.11	27.14
920	27.17	27.20	27.23	27.26	27.29	27.32	27.35	27.37	27.40	27.43
930	27.46	27.49	27.52	27.55	27.58	27.61	27.64	27.67	27.70	27.73
940	27.76	27.79	27.82	27.85	27.88	27.91	27.94	27.97	28.00	28.02
950	28.05	28.08	28.11	28.14	28.17	28.20	28.23	28.26	28.29	28.32
960	28.35	28.38	28.41	28.44	28.47	28.50	28.53	28.56	28.59	28.62
970	28.64	28.67	28.70	28.73	28.76	28.79	28.82	28.85	28.88	28.91
980	28.94	28.97	29.00	29.03	29.06	29.09	29.12	29.15	29.18	29.21
990	29.24	29.26	29.29	29.32	29.35	29.38	29.41	29.44	29.47	29.50
1,000	29.53	29.56	29.59	29.62	29.65	29.68	29.71	29.74	29.77	29.80
1,010	29.83	29.86	29.88	29.91	29.94	29.97	30.00	30.03	30.06	30.09
1,020	30.12	30.15	30.18	30.21	30.24	30.27	30.30	30.33	30.36	30.39
1,030	30.42	30.45	30.48	30.51	30.53	30.56	30.59	30.62	30.65	30.68
1,040	30.71	30.74	30.77	30.80	30.83	30.86	30.89	30.92	30.95	30.98
1,050	31.01	31.04	31.07	31.10	31.13	31.15	31.18	31.21	31.24	31.27
1,060	31.30	31.33	31.36	31.39	31.42	31.45	31.48	31.51	31.54	31.57

MB.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
IN.	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03

To convert millibars given in tenths convert the whole number, then convert the decimal by means of the lower table, and add the results.

Form 2073

APPENDIX III

REDUCED FACSIMILE OF CALIBRATION FORM

AIR MINISTRY METEOROLOGICAL OFFICE

COMPUTATION OF BALLISTIC WINDS AND TEMPERATURES FOR ARTILLERY UNITS

CALIBRATION FIRINGS

Station.....Shoeburyness.... Height.....11.....ft. above M.S.L. Date....3 July, 1941.... Time.....0820.....hrs. G.M.T. Ascent No3.....
1020.....hrs. D.S.T.

Equipment.....Howitzer.....
 Calibre.....9.2-in.....
 Shell design.....Standard.....
 C.R.H. of shell.....4.....
 Wt. of shell.....290 lb.....
 Fuze.....H.E. No. 106E..

Expected M.V.1475.....ft./sec.
 Q.E.40° 11'.....degrees
 T. of F.....48.08.....sec.
 K4.1.....
 Assumed vertex height.....9470.....ft.
 Line of fire.....N. 67° E.....

Percentage Layers	Mid Height of Layers	Components		Resultants		Component along Line of Fire	Line Wind Weighting Factor	Product	Component across Line of Fire	Cross Wind Weighting Factor	Product
		V _E	V _N	Direction (True)	Dir relative to Line of Fire						
% H.T. 0-10	Feet 473	100's ft. min. +10.0	100's ft. min. +1.9	259	192	ft./sec. +16.6	7.1	+117.9	ft./sec. +3.5	11.9	+ 41.7
10-20	1,421	+14.3	+3.0	258	191	+23.5	7.1	+166.9	+4.6	11.0	+ 50.6
20-30	2,367	+12.5	+6.3	243	176	+22.9	7.5	+171.7	-1.6	10.5	- 16.8
30-40	3,315	+13.9	+6.2	246	179	+25.0	12.0	+300.0	-0.4	10.4	- 4.2
40-50	4,261	+14.0	+3.8	255	188	+23.7	15.4	+365.0	+3.3	8.5	+ 28.1
50-60	5,209	*+9.3	+2.6	254	187	+15.8	14.7	+232.3	+1.9	7.5	+ 14.3
60-70	6,155	+11.0	-3.9	290	223	+13.9	7.6	+105.6	+12.9	6.7	+ 86.4
70-80	7,103	+9.6	-6.0	302	235	+10.9	7.0	+76.3	+15.5	7.2	+111.6
80-90	8,049	+9.8	-7.9	309	242	+9.9	8.0	+79.2	+18.5	8.6	+159.1
90-100	8,997	+13.5	-12.9	314	247	+12.1	13.6	+164.6	+28.5	17.7	+504.5
SUM							1,779.5	SUM		975.3	
E.C.L.W.							+17.8	E.C.C.W.		+9.7	

Surface temperature { Dry.....71.2.....°F.
 Wet.....63.0.....°F.

Relative humidity61.....%

Pressure (M.S.L.)30.07 in.

Computers.....AB.....
CD.....

Percentage Layers	Mid Height of Layers	Dry Bulb Temperature	Humidity	Adjusted Temperature	Standard Temperature	Difference	Temperature Weighting Factor	Product
% Ht. 0-10	ft. 473	° F. 70.0	% 62	° F. 70.6	° F. 59.1	° F. +11.5	9.7	+111.5
10-20	1,421	67.4	63	68.0	57.4	+10.6	8.9	+94.3
20-30	2,367	64.8	65	65.4	55.6	+9.8	9.1	+89.2
30-40	3,315	62.1	66	62.7	53.8	+8.9	8.2	+73.0
40-50	4,261	60.4	61	60.8	51.9	+8.9	7.5	+66.7
50-60	5,209	58.9	61	59.3	49.9	+9.4	6.5	+61.1
60-70	6,155	58.3	77	59.3	47.9	+11.4	6.1	+69.5
70-80	7,103	56.7	78	57.8	45.9	+11.9	6.4	+76.2
80-90	8,049	54.0	61	54.4	43.7	+10.7	7.1	+76.0
90-100	8,997	51.2	53	51.3	41.5	+9.8	15.3	+149.9
SUM							+867.4	
BALLISTIC TEMP.							68.7°F.	

APPENDIX

SURFACE TARGET FACTORS

Layer			Mean Components	Layer												
0-500 ft.	500-1,000 ft.	1,000-1,500 ft.		0-2,000 ft.				2,000-4,000 ft.				4,000-6,000 ft.			6,000-8,000 ft.	
20 sec.	20 sec.	20 sec.		30 sec.	40 sec.	50 sec.	60 sec.	30 sec.	40 sec.	50 sec.	60 sec.	40 sec.	50 sec.	60 sec.	50 sec.	60 sec.
.19	.23	.58	1	.47	.21	.13	.09	.53	.25	.15	.10	.54	.17	.11	.19	.1
.4	.5	1.2	2	.9	.4	.3	.2	1.1	.5	.3	.2	1.1	.3	.2	.4	.2
.6	.7	1.7	3	1.4	.6	.4	.3	1.6	.7	.5	.3	1.6	.5	.3	.6	.3
.8	.9	2.3	4	1.9	.8	.5	.4	2.1	1.0	.6	.4	2.2	.7	.4	.8	.4
.9	1.1	2.9	5	2.3	1.1	.7	.5	2.7	1.3	.7	.5	2.7	.9	.5	.9	.5
1.1	1.4	3.5	6	2.8	1.3	.8	.5	3.2	1.5	.9	.6	3.2	1.0	.7	1.1	.7
1.3	1.6	4.1	7	3.3	1.5	.9	.6	3.7	1.7	1.1	.7	3.8	1.2	.8	1.3	.8
1.5	1.8	4.6	8	3.8	1.7	1.0	.7	4.2	2.0	1.2	.8	4.3	1.4	.9	1.5	.9
1.7	2.1	5.2	9	4.2	1.9	1.2	.8	4.8	2.3	1.3	.9	4.9	1.5	1.0	1.7	1.0
1.9	2.3	5.8	10	4.7	2.1	1.3	.9	5.3	2.5	1.5	1.0	5.4	1.7	1.1	1.9	1.1
2.1	2.5	6.4	11	5.2	2.3	1.4	1.0	5.8	2.7	1.7	1.1	5.9	1.9	1.2	2.1	1.2
2.3	2.8	7.0	12	5.6	2.5	1.6	1.1	6.4	3.0	1.8	1.2	6.5	2.0	1.3	2.3	1.3
2.5	3.0	7.5	13	6.1	2.7	1.7	1.2	6.9	3.3	1.9	1.3	7.0	2.2	1.4	2.5	1.4
2.7	3.2	8.1	14	6.6	2.9	1.8	1.3	7.4	3.5	2.1	1.4	7.6	2.4	1.5	2.7	1.5
2.9	3.5	8.7	15	7.1	3.1	1.9	1.3	7.9	3.7	2.3	1.5	8.1	2.5	1.7	2.9	1.7
3.0	3.7	9.3	16	7.5	3.4	2.1	1.4	8.5	4.0	2.4	1.6	8.6	2.7	1.8	3.0	1.8
3.2	3.9	9.9	17	8.0	3.6	2.2	1.5	9.0	4.3	2.5	1.7	9.2	2.9	1.9	3.2	1.9
3.4	4.1	10.4	18	8.5	3.8	2.3	1.6	9.5	4.5	2.7	1.8	9.7	3.1	2.0	3.4	2.0
3.6	4.4	11.0	19	8.9	4.0	2.5	1.7	10.1	4.7	2.9	1.9	10.3	3.2	2.1	3.6	2.1
3.8	4.6	11.6	20	9.4	4.2	2.6	1.8	10.6	5.0	3.0	2.0	10.8	3.4	2.2	3.8	2.2
4.0	4.8	12.2	21	9.9	4.4	2.7	1.9	11.1	5.3	3.1	2.1	11.3	3.6	2.3	4.0	2.3
4.2	5.1	12.8	22	10.3	4.6	2.9	2.0	11.7	5.5	3.3	2.2	11.9	3.7	2.4	4.2	2.4
4.4	5.3	13.3	23	10.8	4.8	3.0	2.1	12.2	5.7	3.5	2.3	12.4	3.9	2.5	4.4	2.5
4.6	5.5	13.9	24	11.3	5.0	3.1	2.2	12.7	6.0	3.6	2.4	13.0	4.1	2.6	4.6	2.6
4.7	5.7	14.5	25	11.7	5.3	3.3	2.3	13.3	6.3	3.7	2.5	13.5	4.3	2.7	4.7	2.7
4.9	6.0	15.1	26	12.2	5.5	3.4	2.3	13.8	6.5	3.9	2.6	14.0	4.4	2.9	4.9	2.9
5.1	6.2	15.7	27	12.7	5.7	3.5	2.4	14.3	6.7	4.1	2.7	14.6	4.6	3.0	5.1	3.0
5.3	6.4	16.2	28	13.2	5.9	3.6	2.5	14.8	7.0	4.2	2.8	15.1	4.8	3.1	5.3	3.1
5.5	6.7	16.8	29	13.6	6.1	3.8	2.6	15.4	7.3	4.3	2.9	15.7	4.9	3.2	5.5	3.2
5.7	6.9	17.4	30	14.1	6.3	3.9	2.7	15.9	7.5	4.5	3.0	16.2	5.1	3.3	5.7	3.3
5.9	7.1	18.0	31	14.6	6.5	4.0	2.8	16.4	7.7	4.7	3.1	16.7	5.3	3.4	5.9	3.4
6.1	7.4	18.6	32	15.0	6.7	4.2	2.9	17.0	8.0	4.8	3.2	17.3	5.4	3.5	6.1	3.5
6.3	7.6	19.1	33	15.5	6.9	4.3	3.0	17.5	8.3	4.9	3.3	17.8	5.6	3.6	6.3	3.6
6.5	7.8	19.7	34	16.0	7.1	4.4	3.1	18.0	8.5	5.1	3.4	18.4	5.8	3.7	6.5	3.7
6.7	8.1	20.3	35	16.5	7.3	4.5	3.1	18.5	8.7	5.3	3.5	18.9	6.0	3.9	6.7	3.9
6.8	8.3	20.9	36	16.9	7.6	4.7	3.2	19.1	9.0	5.4	3.6	19.4	6.1	4.0	6.8	4.0
7.0	8.5	21.5	37	17.4	7.8	4.8	3.3	19.6	9.3	5.5	3.7	20.0	6.3	4.1	7.0	4.1
7.2	8.7	22.0	38	17.9	8.0	4.9	3.4	20.1	9.5	5.7	3.8	20.5	6.5	4.2	7.2	4.2
7.4	9.0	22.6	39	18.3	8.2	5.1	3.5	20.7	9.7	5.9	3.9	21.1	6.6	4.3	7.4	4.3
7.6	9.2	23.2	40	18.8	8.4	5.2	3.6	21.2	10.0	6.0	4.0	21.6	6.8	4.4	7.6	4.4

IV

AND PRODUCTS—WIND

Layer				Mean Components	Layer																	
8,000-10,000 ft.		10,000-12,000 ft.			12,000-14,000 ft.		0-4,000 ft.				4,000-8,000 ft.		8,000-12,000 ft.		12,000-16,000 ft.		16,000-20,000 ft.		20,000-24,000 ft.		24,000-28,000 ft.	
50 sec.	60 sec.	60 sec.	60 sec.		70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.
.36	.13	.15	.31	1	.16	.11	.16	.11	.16	.12	.17	.13	.35	.14	.20						.19	
.7	.3	.3	.6	2	.3	.2	.3	.2	.3	.2	.3	.3	.7	.3	.4						.4	
1.1	.4	.5	.9	3	.5	.3	.5	.3	.5	.4	.5	.4	1.1	.4	.6						.6	
1.4	.5	.6	1.2	4	.6	.4	.6	.4	.6	.5	.7	.5	1.4	.6	.8						.8	
1.8	.7	.7	1.5	5	.8	.5	.8	.5	.8	.6	.9	.7	1.7	.7	1.0						.9	
2.2	.8	.9	1.9	6	1.0	.7	1.0	.7	1.0	.7	1.0	.8	2.1	.8	1.2						1.1	
2.5	.9	1.1	2.2	7	1.1	.8	1.1	.8	1.1	.8	1.2	.9	2.5	1.0	1.4						1.3	
2.9	1.0	1.2	2.5	8	1.3	.9	1.3	.9	1.3	1.0	1.4	1.0	2.8	1.1	1.6						1.5	
3.2	1.2	1.3	2.8	9	1.4	1.0	1.4	1.0	1.4	1.1	1.5	1.2	3.1	1.3	1.8						1.7	
3.6	1.3	1.5	3.1	10	1.6	1.1	1.6	1.1	1.6	1.2	1.7	1.3	3.5	1.4	2.0						1.9	
4.0	1.4	1.6	3.4	11	1.8	1.2	1.8	1.2	1.8	1.3	1.9	1.4	3.9	1.5	2.2						2.1	
4.3	1.6	1.8	3.7	12	1.9	1.3	1.9	1.3	1.9	1.4	2.0	1.6	4.2	1.7	2.4						2.3	
4.7	1.7	1.9	4.0	13	2.1	1.4	2.1	1.4	2.1	1.6	2.2	1.7	4.5	1.8	2.6						2.5	
5.0	1.8	2.1	4.3	14	2.2	1.5	2.2	1.5	2.2	1.7	2.4	1.8	4.9	2.0	2.8						2.7	
5.4	1.9	2.3	4.7	15	2.4	1.7	2.4	1.7	2.4	1.8	2.5	1.9	5.3	2.1	3.0						2.9	
5.8	2.1	2.4	5.0	16	2.6	1.8	2.6	1.8	2.6	1.9	2.7	2.1	5.6	2.2	3.2						3.0	
6.1	2.2	2.5	5.3	17	2.7	1.9	2.7	1.9	2.7	2.0	2.9	2.2	5.9	2.4	3.4						3.2	
6.5	2.3	2.7	5.6	18	2.9	2.0	2.9	2.0	2.9	2.2	3.1	2.3	6.3	2.5	3.6						3.4	
6.8	2.5	2.9	5.9	19	3.0	2.1	3.0	2.1	3.0	2.3	3.2	2.5	6.7	2.7	3.8						3.6	
7.2	2.6	3.0	6.2	20	3.2	2.2	3.2	2.2	3.2	2.4	3.4	2.6	7.0	2.8	4.0						3.8	
7.6	2.7	3.1	6.5	21	3.4	2.3	3.4	2.3	3.4	2.5	3.6	2.7	7.3	2.9	4.2						4.0	
7.9	2.9	3.3	6.8	22	3.5	2.4	3.5	2.4	3.5	2.6	3.7	2.9	7.7	3.1	4.4						4.2	
8.3	3.0	3.5	7.1	23	3.7	2.5	3.7	2.5	3.7	2.8	3.9	3.0	8.1	3.2	4.6						4.4	
8.6	3.1	3.6	7.4	24	3.8	2.6	3.8	2.6	3.8	2.9	4.1	3.1	8.4	3.4	4.8						4.6	
9.0	3.3	3.7	7.7	25	4.0	2.7	4.0	2.7	4.0	3.0	4.3	3.3	8.7	3.5	5.0						4.7	
9.4	3.4	3.9	8.1	26	4.2	2.9	4.2	2.9	4.2	3.1	4.4	3.4	9.1	3.6	5.2						4.9	
9.7	3.5	4.1	8.4	27	4.3	3.0	4.3	3.0	4.3	3.2	4.6	3.5	9.5	3.8	5.4						5.1	
10.1	3.6	4.2	8.7	28	4.5	3.1	4.5	3.1	4.5	3.4	4.8	3.6	9.8	3.9	5.6						5.3	
10.4	3.8	4.3	9.0	29	4.6	3.2	4.6	3.2	4.6	3.5	4.9	3.8	10.1	4.1	5.8						5.5	
10.8	3.9	4.5	9.3	30	4.8	3.3	4.8	3.3	4.8	3.6	5.1	3.9	10.5	4.2	6.0						5.7	
11.2	4.0	4.7	9.6	31	5.0	3.4	5.0	3.4	5.0	3.7	5.3	4.0	10.9	4.3	6.2						5.9	
11.5	4.2	4.8	9.9	32	5.1	3.5	5.1	3.5	5.1	3.8	5.4	4.2	11.2	4.5	6.4						6.1	
11.9	4.3	4.9	10.2	33	5.3	3.6	5.3	3.6	5.3	4.0	5.6	4.3	11.5	4.6	6.6						6.3	
12.2	4.4	5.1	10.5	34	5.4	3.7	5.4	3.7	5.4	4.1	5.8	4.4	11.9	4.8	6.8						6.5	
12.6	4.5	5.3	10.8	35	5.6	3.9	5.6	3.9	5.6	4.2	6.0	4.5	12.3	4.9	7.0						6.7	
13.0	4.7	5.4	11.2	36	5.8	4.0	5.8	4.0	5.8	4.3	6.1	4.7	12.6	5.0	7.2						6.8	
13.3	4.8	5.5	11.5	37	5.9	4.1	5.9	4.1	5.9	4.4	6.3	4.8	12.9	5.2	7.4						7.0	
13.7	4.9	5.7	11.8	38	6.1	4.2	6.1	4.2	6.1	4.6	6.5	4.9	13.3	5.3	7.6						7.2	
14.0	5.1	5.9	12.1	39	6.2	4.3	6.2	4.3	6.2	4.7	6.6	5.1	13.7	5.5	7.8						7.4	
14.4	5.2	6.0	12.4	40	6.4	4.4	6.4	4.4	6.4	4.8	6.8	5.2	14.0	5.6	8.0						7.6	

APPENDIX

SURFACE TARGET FACTORS

Layer					Diff. from Standard °F.	Layer														
100 ft.	300 ft.	250 ft.	750 ft.	1,250 ft.		1,000 ft.					3,000 ft.				5,000 ft.			7,000 ft.		
10 sec.	10 sec.	20 sec.	20 sec.	20 sec.		30 sec.	40 sec.	50 sec.	60 sec.	30 sec.	40 sec.	50 sec.	60 sec.	40 sec.	50 sec.	60 sec.	50 sec.	60 sec.		
.44	.55	.26	.28	.44	1	.45	.22	.11	.05	.49	.24	.13	.07	.43	.14	.08	.16	.09		
.9	1.1	.5	.6	.9	2	.9	.4	.2	.1	1.0	.5	.3	.1	.9	.3	.2	.3	.2		
1.3	1.7	.8	.8	1.3	3	1.3	.7	.3	.1	1.5	.7	.4	.2	1.3	.4	.2	.5	.3		
1.8	2.2	1.0	1.1	1.8	4	1.8	.9	.4	.2	2.0	1.0	.5	.3	1.7	.6	.3	.6	.4		
2.2	2.7	1.3	1.4	2.2	5	2.3	1.1	.5	.3	2.5	1.2	.7	.3	2.1	.7	.4	.8	.5		
2.6	3.3	1.6	1.7	2.6	6	2.7	1.3	.7	.3	2.9	1.4	.8	.4	2.6	.8	.5	1.0	.5		
3.1	3.9	1.8	2.0	3.1	7	3.1	1.5	.8	.3	3.4	1.7	.9	.5	3.0	1.0	.6	1.1	.6		
3.5	4.4	2.1	2.2	3.5	8	3.6	1.8	.9	.4	3.9	1.9	1.0	.6	3.4	1.1	.6	1.3	.7		
4.0	4.9	2.3	2.5	4.0	9	4.1	2.0	1.0	.5	4.4	2.2	1.2	.6	3.9	1.3	.7	1.4	.8		
4.4	5.5	2.6	2.8	4.4	10	4.5	2.2	1.1	.5	4.9	2.4	1.3	.7	4.3	1.4	.8	1.6	.9		
4.8	6.1	2.9	3.1	4.8	11	4.9	2.4	1.2	.5	5.4	2.6	1.4	.8	4.7	1.5	.9	1.8	1.0		
5.3	6.6	3.1	3.4	5.3	12	5.4	2.6	1.3	.6	5.9	2.9	1.6	.8	5.2	1.7	1.0	1.9	1.1		
5.7	7.1	3.4	3.6	5.7	13	5.9	2.9	1.4	.7	6.4	3.1	1.7	.9	5.6	1.8	1.0	2.1	1.2		
6.2	7.7	3.6	3.9	6.2	14	6.3	3.1	1.5	.7	6.9	3.4	1.8	1.0	6.0	2.0	1.1	2.2	1.3		
6.6	8.3	3.9	4.2	6.6	15	6.7	3.3	1.7	.7	7.3	3.6	1.9	1.1	6.5	2.1	1.2	2.4	1.3		
7.0	8.8	4.2	4.5	7.0	16	7.2	3.5	1.8	.8	7.8	3.8	2.1	1.1	6.9	2.2	1.3	2.6	1.4		
7.5	9.3	4.4	4.8	7.5	17	7.7	3.7	1.9	.9	8.3	4.1	2.2	1.2	7.3	2.4	1.4	2.7	1.5		
7.9	9.9	4.7	5.0	7.9	18	8.1	4.0	2.0	.9	8.8	4.3	2.3	1.3	7.7	2.5	1.4	2.9	1.6		
8.4	10.5	4.9	5.3	8.4	19	8.5	4.2	2.1	.9	9.3	4.6	2.5	1.3	8.2	2.7	1.5	3.0	1.7		
8.8	11.0	5.2	5.6	8.8	20	9.0	4.4	2.2	1.0	9.8	4.8	2.6	1.4	8.6	2.8	1.6	3.2	1.8		
9.2	11.5	5.5	5.9	9.2	21	9.5	4.6	2.3	1.1	10.3	5.0	2.7	1.5	9.0	2.9	1.7	3.4	1.9		
9.7	12.1	5.7	6.2	9.7	22	9.9	4.8	2.4	1.1	10.8	5.3	2.9	1.5	9.5	3.1	1.8	3.5	2.0		
10.1	12.7	6.0	6.4	10.1	23	10.3	5.1	2.5	1.1	11.3	5.5	3.0	1.6	9.9	3.2	1.8	3.7	2.1		
10.6	13.2	6.2	6.7	10.6	24	10.8	5.3	2.6	1.2	11.8	5.8	3.1	1.7	10.3	3.4	1.9	3.8	2.2		
11.0	13.8	6.5	7.0	11.0	25	11.3	5.5	2.7	1.3	12.3	6.0	3.3	1.7	10.7	3.5	2.0	4.0	2.3		
11.4	14.3	6.8	7.3	11.4	26	11.7	5.7	2.9	1.3	12.7	6.2	3.4	1.8	11.2	3.6	2.1	4.2	2.3		
11.9	14.9	7.0	7.6	11.9	27	12.1	5.9	3.0	1.3	13.2	6.5	3.5	1.9	11.6	3.8	2.2	4.3	2.4		
12.3	15.4	7.3	7.8	12.3	28	12.6	6.2	3.1	1.4	13.7	6.7	3.6	2.0	12.0	3.9	2.2	4.5	2.5		
12.8	15.9	7.5	8.1	12.8	29	13.1	6.4	3.2	1.5	14.2	7.0	3.8	2.0	12.5	4.1	2.3	4.6	2.6		
13.2	16.5	7.8	8.4	13.2	30	13.5	6.6	3.3	1.5	14.7	7.2	3.9	2.1	12.9	4.2	2.4	4.8	2.7		
13.6	17.1	8.1	8.7	13.6	31	13.9	6.8	3.4	1.5	15.2	7.4	4.0	2.2	13.3	4.3	2.5	5.0	2.8		
14.1	17.6	8.3	9.0	14.1	32	14.4	7.0	3.5	1.6	15.7	7.7	4.2	2.2	13.8	4.5	2.6	5.1	2.9		
14.5	18.2	8.6	9.2	14.5	33	14.9	7.3	3.6	1.7	16.2	7.9	4.3	2.3	14.2	4.6	2.6	5.3	3.0		
15.0	18.7	8.8	9.5	15.0	34	15.3	7.5	3.7	1.7	16.7	8.2	4.4	2.4	14.6	4.8	2.7	5.4	3.1		
15.4	19.3	9.1	9.8	15.4	35	15.7	7.7	3.9	1.7	17.1	8.4	4.5	2.5	15.1	4.9	2.8	5.6	3.1		
15.8	19.8	9.4	10.1	15.8	36	16.2	7.9	4.0	1.8	17.6	8.6	4.7	2.5	15.5	5.0	2.9	5.8	3.2		
16.3	20.4	9.6	10.4	16.3	37	16.7	8.1	4.1	1.9	18.1	8.9	4.8	2.6	15.9	5.2	3.0	5.9	3.3		
16.7	20.9	9.9	10.6	16.7	38	17.1	8.4	4.2	1.9	18.6	9.1	4.9	2.7	16.3	5.3	3.0	6.1	3.4		
17.2	21.5	10.1	10.9	17.2	39	17.5	8.6	4.3	1.9	19.1	9.4	5.1	2.7	16.8	5.5	3.1	6.2	3.5		
17.6	22.0	10.4	11.2	17.6	40	18.0	8.8	4.4	2.0	19.6	9.6	5.2	2.8	17.2	5.6	3.2	6.4	3.6		

V

AND PRODUCTS—TEMPERATURE

Layer				Diff. from Standard °F.	Layer															
9,000 ft.		11,000 ft.	13,000 ft.		2,000 ft.		6,000 ft.		10,000 ft.		14,000 ft.		18,000 ft.		22,000 ft.	26,000 ft.				
50 sec.	60 sec.	60 sec.	60 sec.		70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	70 sec.	80 sec.	80 sec.	80 sec.				
.28	.10	.11	.27	1	.08	.06	.09	.07	.10	.07	.13	.08	.29	.08	.11	.11				
.6	.2	.2	.5	2	.2	.1	.2	.1	.2	.1	.3	.2	.6	.2	.2	.2				
.8	.3	.3	.8	3	.2	.2	.3	.2	.3	.2	.4	.2	.9	.2	.3	.3				
1.1	.4	.4	1.1	4	.3	.2	.4	.3	.4	.3	.5	.3	1.2	.3	.4	.4				
1.4	.5	.5	1.3	5	.4	.3	.5	.3	.5	.3	.7	.4	1.5	.4	.5	.5				
1.7	.6	.7	1.6	6	.5	.4	.5	.4	.6	.4	.8	.5	1.7	.5	.7	.7				
2.0	.7	.8	1.9	7	.6	.4	.6	.5	.7	.5	.9	.6	2.0	.6	.8	.8				
2.2	.8	.9	2.2	8	.6	.5	.7	.6	.8	.6	1.0	.6	2.3	.6	.9	.9				
2.5	.9	1.0	2.4	9	.7	.5	.8	.6	.9	.6	1.2	.7	2.6	.7	1.0	1.0				
2.8	1.0	1.1	2.7	10	.8	.6	.9	.7	1.0	.7	1.3	.8	2.9	.8	1.1	1.1				
3.1	1.1	1.2	3.0	11	.9	.7	1.0	.8	1.1	.8	1.4	.9	3.2	.9	1.2	1.2				
3.4	1.2	1.3	3.2	12	1.0	.7	1.1	.8	1.2	.8	1.6	1.0	3.5	1.0	1.3	1.3				
3.6	1.3	1.4	3.5	13	1.0	.8	1.2	.9	1.3	.9	1.7	1.0	3.8	1.0	1.4	1.4				
3.9	1.4	1.5	3.8	14	1.1	.8	1.3	1.0	1.4	1.0	1.8	1.1	4.1	1.1	1.5	1.5				
4.2	1.5	1.7	4.1	15	1.2	.9	1.3	1.1	1.5	1.1	1.9	1.2	4.3	1.2	1.7	1.7				
4.5	1.6	1.8	4.3	16	1.3	1.0	1.4	1.1	1.6	1.1	2.1	1.3	4.6	1.3	1.8	1.8				
4.8	1.7	1.9	4.6	17	1.4	1.0	1.5	1.2	1.7	1.2	2.2	1.4	4.9	1.4	1.9	1.9				
5.0	1.8	2.0	4.9	18	1.4	1.1	1.6	1.3	1.8	1.3	2.3	1.4	5.2	1.4	2.0	2.0				
5.3	1.9	2.1	5.1	19	1.5	1.1	1.7	1.3	1.9	1.3	2.5	1.5	5.5	1.5	2.1	2.1				
5.6	2.0	2.2	5.4	20	1.6	1.2	1.8	1.4	2.0	1.4	2.6	1.6	5.8	1.6	2.2	2.2				
5.9	2.1	2.3	5.7	21	1.7	1.3	1.9	1.5	2.1	1.5	2.7	1.7	6.1	1.7	2.3	2.3				
6.2	2.2	2.4	5.9	22	1.8	1.3	2.0	1.5	2.2	1.5	2.9	1.8	6.4	1.8	2.4	2.4				
6.4	2.3	2.5	6.2	23	1.8	1.4	2.1	1.6	2.3	1.6	3.0	1.8	6.7	1.8	2.5	2.5				
6.7	2.4	2.6	6.5	24	1.9	1.4	2.2	1.7	2.4	1.7	3.1	1.9	7.0	1.9	2.6	2.6				
7.0	2.5	2.7	6.7	25	2.0	1.5	2.3	1.7	2.5	1.7	3.3	2.0	7.3	2.0	2.7	2.7				
7.3	2.6	2.9	7.0	26	2.1	1.6	2.3	1.8	2.6	1.8	3.4	2.1	7.5	2.1	2.9	2.9				
7.6	2.7	3.0	7.3	27	2.2	1.6	2.4	1.9	2.7	1.9	3.5	2.2	7.8	2.2	3.0	3.0				
7.8	2.8	3.1	7.6	28	2.2	1.7	2.5	2.0	2.8	2.0	3.6	2.2	8.1	2.2	3.1	3.1				
8.1	2.9	3.2	7.8	29	2.3	1.7	2.6	2.0	2.9	2.0	3.8	2.3	8.4	2.3	3.2	3.2				
8.4	3.0	3.3	8.1	30	2.4	1.8	2.7	2.1	3.0	2.1	3.9	2.4	8.7	2.4	3.3	3.3				
8.7	3.1	3.4	8.4	31	2.5	1.9	2.8	2.2	3.1	2.2	4.0	2.5	9.0	2.5	3.4	3.4				
9.0	3.2	3.5	8.6	32	2.6	1.9	2.9	2.2	3.2	2.2	4.2	2.6	9.3	2.6	3.5	3.5				
9.2	3.3	3.6	8.9	33	2.6	2.0	3.0	2.3	3.3	2.3	4.3	2.6	9.6	2.6	3.6	3.6				
9.5	3.4	3.7	9.2	34	2.7	2.0	3.1	2.4	3.4	2.4	4.4	2.7	9.9	2.7	3.7	3.7				
9.8	3.5	3.9	9.5	35	2.8	2.1	3.1	2.5	3.5	2.5	4.5	2.8	10.1	2.8	3.9	3.9				
10.1	3.6	4.0	9.7	36	2.9	2.2	3.2	2.5	3.6	2.5	4.7	2.9	10.4	2.9	4.0	4.0				
10.4	3.7	4.1	10.0	37	3.0	2.2	3.3	2.6	3.7	2.6	4.8	3.0	10.7	3.0	4.1	4.1				
10.6	3.8	4.2	10.3	38	3.0	2.3	3.4	2.7	3.8	2.7	4.9	3.0	11.0	3.0	4.2	4.2				
10.9	3.9	4.3	10.5	39	3.1	2.3	3.5	2.7	3.9	2.7	5.1	3.1	11.3	3.1	4.3	4.3				
11.2	4.0	4.4	10.8	40	3.2	2.4	3.6	2.8	4.0	2.8	5.2	3.2	11.6	3.2	4.4	4.4				

APPENDIX VI

A.A. FACTORS AND PRODUCTS—WIND

Mean Com- ponents	0-2,000 ft. layer										2,000-4,000 ft. layer										Mean Com- ponents
	Height of vertex (ft.)										Height of vertex (ft.)										
	4,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	4,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	
1	0.71	0.33	0.25	0.18	0.16	0.13	0.11	0.10	0.10	0.09	0.29	0.32	0.24	0.19	0.16	0.13	0.10	0.10	0.09	0.08	1
2	1.4	0.7	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.6	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	2
3	2.1	1.0	0.7	0.5	0.3	0.4	0.3	0.3	0.3	0.3	0.9	1.0	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.3	3
4	2.8	1.3	1.0	0.7	0.6	0.5	0.4	0.4	0.4	0.4	1.2	1.3	1.0	0.8	0.6	0.5	0.4	0.4	0.4	0.4	4
5	3.5	1.7	1.3	0.9	0.8	0.7	0.5	0.5	0.5	0.5	1.5	1.6	1.2	0.9	0.8	0.7	0.5	0.5	0.5	0.4	5
6	4.3	2.0	1.5	1.1	1.0	0.8	0.7	0.6	0.6	0.5	1.7	1.9	1.4	1.1	1.0	0.8	0.6	0.6	0.5	0.5	6
7	5.0	2.3	1.7	1.3	1.1	0.9	0.8	0.7	0.7	0.6	2.0	2.2	1.7	1.3	1.1	0.9	0.7	0.7	0.6	0.6	7
8	5.7	2.6	2.0	1.4	1.3	1.0	0.9	0.8	0.8	0.7	2.3	2.6	1.9	1.5	1.3	1.0	0.8	0.8	0.7	0.6	8
9	6.4	3.0	2.3	1.6	1.4	1.2	1.0	0.9	0.9	0.8	2.6	2.9	2.2	1.7	1.4	1.2	0.9	0.9	0.8	0.7	9
10	7.1	3.3	2.5	1.8	1.6	1.3	1.1	1.0	1.0	0.9	2.9	3.2	2.4	1.9	1.6	1.3	1.0	1.0	0.9	0.8	10
11	7.8	3.6	2.7	2.0	1.8	1.4	1.2	1.1	1.1	1.0	3.2	3.5	2.6	2.1	1.8	1.4	1.1	1.1	1.0	0.9	11
12	8.5	4.0	3.0	2.2	1.9	1.6	1.3	1.2	1.2	1.1	3.5	3.8	2.9	2.3	1.9	1.6	1.2	1.2	1.1	1.0	12
13	9.2	4.3	3.3	2.3	2.1	1.7	1.4	1.3	1.3	1.2	3.8	4.2	3.1	2.5	2.1	1.7	1.3	1.3	1.2	1.1	13
14	9.9	4.6	3.5	2.5	2.2	1.8	1.5	1.4	1.4	1.3	4.1	4.5	3.4	2.7	2.2	1.8	1.4	1.4	1.3	1.1	14
15	10.7	5.0	3.7	2.7	2.4	1.9	1.7	1.5	1.5	1.3	4.3	4.8	3.6	2.9	2.4	1.9	1.5	1.5	1.3	1.2	15
16	11.4	5.3	4.0	2.9	2.6	2.1	1.8	1.6	1.6	1.4	4.6	5.1	3.8	3.0	2.6	2.1	1.6	1.6	1.4	1.3	16
17	12.1	5.6	4.3	3.1	2.7	2.2	1.9	1.7	1.7	1.5	4.9	5.4	4.1	3.2	2.7	2.2	1.7	1.7	1.5	1.4	17
18	12.8	5.9	4.5	3.2	2.9	2.3	2.0	1.8	1.8	1.6	5.2	5.8	4.3	3.4	2.9	2.3	1.8	1.8	1.6	1.4	18
19	13.5	6.3	4.7	3.4	3.0	2.5	2.1	1.9	1.9	1.7	5.5	6.1	4.6	3.6	3.0	2.5	1.9	1.9	1.7	1.5	19
20	14.2	6.6	5.0	3.6	3.2	2.6	2.2	2.0	2.0	1.8	5.8	6.4	4.8	3.8	3.2	2.6	2.0	2.0	1.8	1.6	20
21	14.9	6.9	5.3	3.8	3.4	2.7	2.3	2.1	2.1	1.9	6.1	6.7	5.0	4.0	3.4	2.7	2.1	2.1	1.9	1.7	21
22	15.6	7.3	5.5	4.0	3.5	2.9	2.4	2.2	2.2	2.0	6.4	7.0	5.3	4.2	3.5	2.9	2.2	2.2	2.0	1.8	22
23	16.3	7.6	5.7	4.1	3.6	3.0	2.5	2.3	2.3	2.1	6.7	7.4	5.5	4.4	3.7	3.0	2.3	2.3	2.1	1.8	23
24	17.0	7.9	6.0	4.3	3.8	3.1	2.6	2.4	2.4	2.2	7.0	7.7	5.8	4.6	3.8	3.1	2.4	2.4	2.2	1.9	24
25	17.7	8.3	6.3	4.5	4.0	3.3	2.7	2.5	2.5	2.3	7.3	8.0	6.0	4.7	4.0	3.3	2.5	2.5	2.3	2.0	25
26	18.5	8.6	6.5	4.7	4.2	3.4	2.9	2.6	2.6	2.3	7.5	8.3	6.2	4.9	4.2	3.4	2.6	2.6	2.3	2.1	26
27	19.2	8.9	6.7	4.9	4.3	3.5	3.0	2.7	2.7	2.4	7.8	8.6	6.5	5.1	4.3	3.5	2.7	2.7	2.4	2.2	27
28	19.9	9.2	7.0	5.0	4.5	3.6	3.1	2.8	2.8	2.5	8.1	9.0	7.0	5.3	4.5	3.6	2.8	2.8	2.5	2.3	28
29	20.6	9.6	7.3	5.2	4.6	3.8	3.2	2.9	2.9	2.6	8.4	9.3	7.0	5.5	4.6	3.8	2.9	2.9	2.6	2.3	29
30	21.3	9.9	7.5	5.4	4.8	3.9	3.3	3.0	3.0	2.7	8.7	9.6	7.2	5.7	4.8	3.9	3.0	3.0	2.7	2.4	30

APPENDIX VI—continued
A.A. FACTORS AND PRODUCTS—WIND

Mean Compo- nents	4,000-6,000 ft. layer										6,000-8,000 ft. layer										Mean Compo- nents
	Height of vertex (ft.)										Height of vertex (ft.)										
	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000			
1	0.26	0.22	* 0.18	0.15	0.13	0.10	0.10	0.09	0.08	0.09	0.16	0.17	0.14	0.12	0.10	0.10	0.09	0.08	1		
2	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	2		
3	0.8	0.7	0.5	0.4	0.4	0.3	0.3	0.3	0.2	0.3	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	3		
4	1.0	0.9	0.7	0.6	0.5	0.4	0.4	0.4	0.3	0.4	0.6	0.7	0.6	0.5	0.4	0.4	0.4	0.4	4		
5	1.3	1.1	0.9	0.7	0.7	0.5	0.5	0.5	0.4	0.5	0.8	0.9	0.7	0.6	0.5	0.5	0.5	0.4	5		
6	1.6	1.3	1.1	0.9	0.8	0.6	0.6	0.5	0.5	0.5	1.0	1.0	0.8	0.7	0.6	0.6	0.5	0.5	6		
7	1.8	1.5	1.3	1.1	0.9	0.7	0.7	0.6	0.6	0.6	1.1	1.2	1.0	0.8	0.7	0.7	0.6	0.6	7		
8	2.1	1.8	1.4	1.2	1.0	0.8	0.8	0.7	0.6	0.7	1.3	1.4	1.1	1.0	0.8	0.8	0.7	0.6	8		
9	2.3	2.0	1.6	1.3	1.2	0.9	0.9	0.8	0.7	0.8	1.4	1.5	1.3	1.1	0.9	0.9	0.8	0.7	9		
10	2.6	2.2	1.8	1.5	1.3	1.0	1.0	0.9	0.8	0.9	1.6	1.7	1.4	1.2	1.0	1.0	0.9	0.8	10		
11	2.9	2.4	2.0	1.7	1.4	1.1	1.1	1.0	0.9	1.0	1.8	1.9	1.5	1.3	1.1	1.1	1.0	0.9	11		
12	3.1	2.6	2.2	1.8	1.6	1.2	1.2	1.1	1.0	1.1	1.9	2.0	1.7	1.4	1.2	1.2	1.1	1.0	12		
13	3.4	2.9	2.3	1.9	1.7	1.3	1.3	1.2	1.0	1.2	2.1	2.2	1.8	1.6	1.3	1.3	1.2	1.0	13		
14	3.6	3.1	2.5	2.1	1.8	1.4	1.4	1.3	1.1	1.3	2.2	2.4	2.0	1.7	1.4	1.4	1.3	1.1	14		
15	3.9	3.3	2.7	2.3	1.9	1.5	1.5	1.3	1.2	1.3	2.4	2.5	2.1	1.8	1.5	1.5	1.3	1.2	15		
16	4.2	3.5	2.9	2.4	2.1	1.6	1.6	1.4	1.3	1.4	2.6	2.7	2.2	1.9	1.6	1.6	1.4	1.3	16		
17	4.4	3.7	3.1	2.5	2.2	1.7	1.7	1.5	1.4	1.5	2.7	2.9	2.4	2.0	1.7	1.7	1.5	1.4	17		
18	4.7	4.0	3.2	2.7	2.3	1.8	1.8	1.6	1.4	1.6	2.9	3.1	2.5	2.2	1.8	1.8	1.6	1.4	18		
19	4.9	4.2	3.4	2.9	2.5	1.9	1.9	1.7	1.5	1.7	3.0	3.2	2.7	2.3	1.9	1.9	1.7	1.5	19		
20	5.2	4.4	3.6	3.0	2.6	2.0	2.0	1.8	1.6	1.8	3.2	3.4	2.8	2.4	2.0	2.0	1.8	1.6	20		
21	5.5	4.6	3.8	3.1	2.7	2.1	2.1	1.9	1.7	1.9	3.4	3.6	2.9	2.5	2.1	2.1	1.9	1.7	21		
22	5.7	4.8	4.0	3.3	2.9	2.2	2.2	2.0	1.8	2.0	3.5	3.7	3.1	2.6	2.2	2.2	2.0	1.8	22		
23	6.0	5.1	4.1	3.5	3.0	2.3	2.3	2.1	1.8	2.1	3.7	3.9	3.2	2.8	2.3	2.3	2.1	1.8	23		
24	6.2	5.3	4.3	3.6	3.1	2.4	2.4	2.2	1.9	2.2	3.8	4.1	3.4	2.9	2.4	2.4	2.2	1.9	24		
25	6.5	5.5	4.5	3.7	3.3	2.5	2.5	2.3	2.0	2.3	4.0	4.3	3.5	3.0	2.5	2.5	2.3	2.0	25		
26	6.8	5.7	4.7	3.9	3.4	2.6	2.6	2.3	2.1	2.3	4.2	4.4	3.6	3.1	2.6	2.6	2.3	2.1	26		
27	7.0	5.9	4.9	4.1	3.5	2.7	2.7	2.4	2.2	2.4	4.3	4.6	3.8	3.2	2.7	2.7	2.4	2.2	27		
28	7.3	6.2	5.0	4.2	3.6	2.8	2.8	2.5	2.2	2.5	4.5	4.8	3.9	3.4	2.8	2.8	2.5	2.2	28		
29	7.5	6.4	5.2	4.3	3.8	2.9	2.9	2.6	2.3	2.6	4.6	4.9	4.1	3.5	2.9	2.9	2.6	2.3	29		
30	7.8	6.6	5.4	4.5	4.0	3.0	3.0	2.7	2.4	2.7	4.8	5.1	4.2	3.6	3.0	3.0	2.7	2.4	30		

APPENDIX VI—continued
A.A. FACTORS AND PRODUCTS—WIND

Mean Compo- nents	8,000–10,000 ft. layer										10,000–12,000 ft. layer										Mean Compo- nents
	Height of vertex (ft.)										Height of vertex (ft.)										
	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000					
1	0.10	0.13	0.12	0.11	0.10	0.10	0.09	0.08	0.03	0.08	0.10	0.10	0.09	0.09	0.08	0.07	1				
2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	2				
3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.1	0.2	0.3	0.3	0.3	0.3	0.2	0.2	3				
4	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.1	0.3	0.4	0.4	0.4	0.4	0.3	0.3	4				
5	0.5	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.1	0.4	0.5	0.5	0.5	0.5	0.4	0.3	5				
6	0.6	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.2	0.5	0.6	0.6	0.5	0.5	0.4	0.4	6				
7	0.7	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.2	0.6	0.7	0.7	0.6	0.6	0.5	0.5	7				
8	0.8	1.0	1.0	0.9	0.8	0.8	0.7	0.6	0.2	0.6	0.8	0.8	0.7	0.7	0.6	0.6	8				
9	0.9	1.2	1.1	1.0	0.9	0.9	0.8	0.7	0.3	0.7	0.9	0.9	0.8	0.8	0.7	0.6	9				
10	1.0	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.3	0.8	1.0	1.0	0.9	0.9	0.8	0.7	10				
11	1.1	1.4	1.3	1.2	1.1	1.1	1.0	0.9	0.3	0.9	1.1	1.1	1.0	1.0	0.9	0.8	11				
12	1.2	1.6	1.4	1.3	1.2	1.2	1.1	1.0	0.4	1.0	1.2	1.2	1.1	1.1	1.0	0.8	12				
13	1.3	1.7	1.6	1.4	1.3	1.3	1.2	1.0	0.4	1.0	1.3	1.3	1.2	1.2	1.0	0.9	13				
14	1.4	1.8	1.7	1.5	1.4	1.4	1.3	1.1	0.4	1.1	1.4	1.4	1.3	1.3	1.1	1.0	14				
15	1.5	1.9	1.8	1.7	1.5	1.5	1.3	1.2	0.5	1.2	1.5	1.5	1.3	1.3	1.2	1.1	15				
16	1.6	2.1	1.9	1.8	1.6	1.6	1.4	1.3	0.5	1.3	1.6	1.6	1.4	1.4	1.3	1.1	16				
17	1.7	2.2	2.0	1.9	1.7	1.7	1.5	1.4	0.5	1.4	1.7	1.7	1.5	1.5	1.4	1.2	17				
18	1.8	2.3	2.2	2.0	1.8	1.8	1.6	1.4	0.5	1.4	1.8	1.8	1.6	1.6	1.4	1.3	18				
19	1.9	2.5	2.3	2.1	1.9	1.9	1.7	1.5	0.6	1.5	1.9	1.9	1.7	1.7	1.5	1.3	19				
20	2.0	2.6	2.4	2.2	2.0	2.0	1.8	1.6	0.6	1.6	2.0	2.0	1.8	1.8	1.6	1.4	20				
21	2.1	2.7	2.5	2.3	2.1	2.1	1.9	1.7	0.6	1.7	2.1	2.1	1.9	1.9	1.7	1.5	21				
22	2.2	2.9	2.6	2.4	2.2	2.2	2.0	1.8	0.7	1.8	2.2	2.2	2.0	2.0	1.8	1.5	22				
23	2.3	3.0	2.8	2.5	2.3	2.3	2.1	1.8	0.7	1.8	2.3	2.3	2.1	2.1	1.8	1.6	23				
24	2.4	3.1	2.9	2.6	2.4	2.4	2.2	1.9	0.7	1.9	2.4	2.4	2.2	2.2	1.9	1.7	24				
25	2.5	3.3	3.0	2.7	2.5	2.5	2.3	2.0	0.7	2.0	2.5	2.5	2.3	2.3	2.0	1.7	25				
26	2.6	3.4	3.1	2.9	2.6	2.6	2.3	2.1	0.8	2.1	2.6	2.6	2.3	2.3	2.1	1.8	26				
27	2.7	3.5	3.2	3.0	2.7	2.7	2.4	2.2	0.8	2.2	2.7	2.7	2.4	2.4	2.2	1.9	27				
28	2.8	3.6	3.4	3.1	2.8	2.8	2.5	2.2	0.8	2.2	2.8	2.8	2.5	2.5	2.2	2.0	28				
29	2.9	3.8	3.5	3.2	2.9	2.9	2.6	2.3	0.9	2.3	2.9	2.9	2.6	2.6	2.3	2.0	29				
30	3.0	3.9	3.6	3.3	3.0	3.0	2.7	2.4	0.9	2.4	3.0	3.0	2.7	2.7	2.4	2.1	30				

APPENDIX VI—continued
A.A. FACTORS AND PRODUCTS—WIND

Mean Compo- nents	12,000-14,000 ft. layer										14,000-16,000 ft. layer										Mean Compo- nents
	Height of vertex (ft.)										Height of vertex (ft.)										
	16,000	20,000	24,000	28,000	32,000	36,000	40,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000							
1	0.05	0.07	0.08	0.08	0.09	0.07	0.07	0.02	0.06	0.07	0.08	0.08	0.07	0.07	0.07	1					
2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.1	2					
3	0.1	0.2	0.3	0.3	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	3					
4	0.2	0.3	0.4	0.4	0.4	0.3	0.3	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	4					
5	0.3	0.3	0.4	0.4	0.5	0.3	0.3	0.1	0.3	0.3	0.4	0.4	0.3	0.3	0.3	5					
6	0.3	0.4	0.5	0.5	0.5	0.4	0.4	0.1	0.4	0.4	0.5	0.5	0.4	0.4	0.4	6					
7	0.3	0.5	0.6	0.6	0.6	0.5	0.5	0.1	0.4	0.5	0.6	0.6	0.5	0.5	0.5	7					
8	0.4	0.6	0.7	0.7	0.7	0.6	0.6	0.2	0.5	0.6	0.6	0.6	0.6	0.6	0.6	8					
9	0.5	0.6	0.7	0.7	0.8	0.6	0.6	0.2	0.5	0.6	0.7	0.7	0.6	0.6	0.6	9					
10	0.5	0.7	0.8	0.8	0.9	0.7	0.7	0.2	0.6	0.7	0.8	0.8	0.7	0.7	0.7	10					
11	0.5	0.8	0.9	0.9	1.0	0.8	0.8	0.2	0.7	0.8	0.9	0.9	0.8	0.8	0.8	11					
12	0.6	0.8	1.0	1.0	1.1	0.9	0.9	0.2	0.7	0.8	1.0	1.0	0.8	0.8	0.8	12					
13	0.7	0.9	1.0	1.0	1.2	0.9	0.9	0.3	0.8	0.9	1.0	1.0	0.9	0.9	0.9	13					
14	0.7	1.0	1.1	1.1	1.3	1.0	1.0	0.3	0.8	1.0	1.1	1.1	1.0	1.0	1.0	14					
15	0.7	1.1	1.2	1.2	1.3	1.1	1.1	0.3	0.9	1.1	1.2	1.2	1.1	1.1	1.1	15					
16	0.8	1.1	1.3	1.3	1.4	1.1	1.1	0.3	1.0	1.1	1.3	1.3	1.1	1.1	1.1	16					
17	0.9	1.2	1.4	1.4	1.5	1.2	1.2	0.3	1.0	1.2	1.4	1.4	1.2	1.2	1.2	17					
18	0.9	1.3	1.4	1.4	1.6	1.3	1.3	0.4	1.1	1.3	1.4	1.4	1.3	1.3	1.3	18					
19	0.9	1.3	1.5	1.5	1.7	1.3	1.3	0.4	1.1	1.3	1.5	1.5	1.3	1.3	1.3	19					
20	1.0	1.4	1.6	1.6	1.8	1.4	1.4	0.4	1.2	1.4	1.6	1.6	1.4	1.4	1.4	20					
21	1.1	1.5	1.7	1.7	1.9	1.5	1.5	0.4	1.3	1.5	1.7	1.7	1.5	1.5	1.5	21					
22	1.1	1.5	1.8	1.8	2.0	1.6	1.6	0.4	1.3	1.5	1.8	1.8	1.5	1.5	1.5	22					
23	1.1	1.6	1.8	1.8	2.1	1.6	1.6	0.5	1.4	1.6	1.9	1.9	1.6	1.6	1.6	23					
24	1.2	1.7	1.9	1.9	2.2	1.7	1.7	0.5	1.4	1.7	2.0	2.0	1.7	1.7	1.7	24					
25	1.3	1.7	2.0	2.0	2.3	1.7	1.7	0.5	1.5	1.7	2.0	2.0	1.7	1.7	1.7	25					
26	1.3	1.8	2.1	2.1	2.3	1.8	1.8	0.5	1.6	1.8	2.1	2.1	1.8	1.8	1.8	26					
27	1.3	1.9	2.2	2.2	2.4	1.9	1.9	0.5	1.6	1.9	2.2	2.2	1.9	1.9	1.9	27					
28	1.4	2.0	2.3	2.3	2.5	2.0	2.0	0.6	1.7	2.0	2.3	2.3	2.0	2.0	2.0	28					
29	1.5	2.0	2.4	2.4	2.6	2.1	2.1	0.6	1.7	2.1	2.4	2.4	2.1	2.1	2.1	29					
30	1.5	2.1	2.5	2.5	2.7	2.2	2.2	0.6	1.8	2.2	2.5	2.5	2.2	2.2	2.2	30					

APPENDIX VI—continued
A.A. FACTORS AND PRODUCTS—WIND

Mean Components	16,000-20,000 ft. layer					20,000-24,000 ft. layer					Mean Components
	Height of vertex (ft.)					Height of vertex (ft.)					
	20,000	24,000	28,000	32,000	40,000	24,000	28,000	32,000	36,000	40,000	
1	0.04	0.10	0.12	0.13	0.12	0.03	0.09	0.07	0.10	0.11	1
2	0.1	0.2	0.2	0.3	0.2	0.1	0.2	0.1	0.2	0.2	2
3	0.1	0.3	0.4	0.4	0.4	0.1	0.3	0.2	0.3	0.3	3
4	0.2	0.4	0.5	0.5	0.5	0.1	0.4	0.3	0.4	0.4	4
5	0.2	0.5	0.6	0.7	0.6	0.1	0.5	0.3	0.5	0.5	5
6	0.2	0.6	0.7	0.8	0.7	0.2	0.5	0.4	0.6	0.7	6
7	0.3	0.7	0.8	0.9	0.8	0.2	0.6	0.5	0.7	0.8	7
8	0.3	0.8	1.0	1.0	1.0	0.2	0.7	0.6	0.8	0.9	8
9	0.4	0.9	1.1	1.2	1.1	0.3	0.8	0.6	0.9	1.0	9
10	0.4	1.0	1.2	1.3	1.2	0.3	0.9	0.7	1.0	1.1	10
11	0.4	1.1	1.3	1.4	1.3	0.3	1.0	0.8	1.1	1.2	11
12	0.5	1.2	1.4	1.6	1.4	0.4	1.1	0.8	1.2	1.3	12
13	0.5	1.3	1.6	1.7	1.6	0.4	1.2	0.9	1.3	1.4	13
14	0.6	1.4	1.7	1.8	1.7	0.4	1.3	1.0	1.4	1.5	14
15	0.6	1.5	1.8	1.9	1.8	0.5	1.3	1.1	1.5	1.7	15
16	0.6	1.6	1.9	2.1	1.9	0.5	1.4	1.1	1.6	1.8	16
17	0.7	1.7	2.0	2.2	2.0	0.5	1.5	1.2	1.7	1.9	17
18	0.7	1.8	2.2	2.3	2.2	0.5	1.6	1.3	1.8	2.0	18
19	0.8	1.9	2.3	2.5	2.3	0.6	1.7	1.3	1.9	2.1	19
20	0.8	2.0	2.4	2.6	2.4	0.6	1.8	1.4	2.0	2.2	20
21	0.8	2.1	2.5	2.7	2.5	0.6	1.9	1.5	2.1	2.3	21
22	0.9	2.2	2.6	2.9	2.6	0.7	2.0	1.5	2.2	2.4	22
23	0.9	2.3	2.8	3.0	2.8	0.7	2.1	1.6	2.3	2.5	23
24	1.0	2.4	2.9	3.1	2.9	0.7	2.2	1.7	2.4	2.6	24
25	1.0	2.5	3.0	3.3	3.0	0.7	2.3	1.7	2.5	2.7	25
26	1.0	2.6	3.1	3.4	3.1	0.8	2.3	1.8	2.6	2.9	26
27	1.1	2.7	3.2	3.5	3.2	0.8	2.4	1.9	2.7	3.0	27
28	1.1	2.8	3.4	3.6	3.4	0.8	2.5	2.0	2.8	3.1	28
29	1.2	2.9	3.5	3.8	3.5	0.9	2.6	2.0	2.9	3.2	29
30	1.2	3.0	3.6	3.9	3.6	0.9	2.7	2.1	3.0	3.3	30

APPENDIX VI—continued
A.A. FACTORS AND PRODUCTS—WIND

Mean Components	24,000–28,000 ft. layer				28,000–32,000 ft. layer				32,000–36,000 ft. layer				36,000–40,000 ft. layer				Mean Components
	Height of vertex (ft.)				Height of vertex (ft.)				Height of vertex (ft.)				Height of vertex (ft.)				
	28,000	32,000	36,000	40,000	32,000	36,000	40,000	36,000	40,000	36,000	40,000	36,000	40,000				
1	0.03	0.03	0.06	0.08	0.01	0.03	0.04	0.01	0.02	0.01	0.01	0.01	0.01	0.01	1		
2	0.1	0.1	0.1	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2		
3	0.1	0.1	0.2	0.2	0.0	0.1	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.0	3		
4	0.1	0.1	0.2	0.3	0.0	0.1	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.0	4		
5	0.1	0.1	0.3	0.4	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	5		
6	0.2	0.2	0.4	0.5	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	6		
7	0.2	0.2	0.4	0.6	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	7		
8	0.2	0.2	0.5	0.6	0.1	0.2	0.3	0.2	0.2	0.1	0.2	0.2	0.1	0.1	8		
9	0.3	0.3	0.5	0.7	0.1	0.3	0.4	0.3	0.2	0.1	0.2	0.2	0.1	0.1	9		
10	0.3	0.3	0.6	0.8	0.1	0.3	0.4	0.3	0.2	0.1	0.2	0.2	0.1	0.1	10		
11	0.3	0.3	0.7	0.9	0.1	0.3	0.4	0.3	0.2	0.1	0.2	0.2	0.1	0.1	11		
12	0.4	0.4	0.7	1.0	0.1	0.4	0.5	0.4	0.2	0.1	0.2	0.2	0.1	0.1	12		
13	0.4	0.4	0.8	1.0	0.1	0.4	0.5	0.4	0.3	0.1	0.3	0.3	0.1	0.1	13		
14	0.4	0.4	0.8	1.1	0.1	0.4	0.6	0.4	0.3	0.1	0.3	0.3	0.1	0.1	14		
15	0.5	0.5	0.9	1.2	0.1	0.5	0.6	0.5	0.3	0.1	0.3	0.3	0.1	0.1	15		
16	0.5	0.5	1.0	1.3	0.2	0.5	0.6	0.5	0.3	0.2	0.3	0.3	0.2	0.2	16		
17	0.5	0.5	1.0	1.4	0.2	0.5	0.7	0.5	0.3	0.2	0.3	0.3	0.2	0.2	17		
18	0.5	0.5	1.1	1.4	0.2	0.5	0.7	0.5	0.4	0.2	0.4	0.4	0.2	0.2	18		
19	0.6	0.6	1.1	1.5	0.2	0.6	0.8	0.6	0.4	0.2	0.4	0.4	0.2	0.2	19		
20	0.6	0.6	1.2	1.6	0.2	0.6	0.8	0.6	0.4	0.2	0.4	0.4	0.2	0.2	20		
21	0.6	0.6	1.3	1.7	0.2	0.6	0.8	0.6	0.4	0.2	0.4	0.4	0.2	0.2	21		
22	0.7	0.7	1.3	1.8	0.2	0.7	0.9	0.7	0.4	0.2	0.4	0.4	0.2	0.2	22		
23	0.7	0.7	1.4	1.8	0.2	0.7	0.9	0.7	0.5	0.2	0.5	0.5	0.2	0.2	23		
24	0.7	0.7	1.4	1.9	0.2	0.7	1.0	0.7	0.5	0.2	0.5	0.5	0.2	0.2	24		
25	0.7	0.7	1.5	2.0	0.3	0.7	1.0	0.7	0.5	0.3	0.5	0.5	0.3	0.3	25		
26	0.8	0.8	1.6	2.1	0.3	0.8	1.0	0.8	0.5	0.3	0.5	0.5	0.3	0.3	26		
27	0.8	0.8	1.6	2.2	0.3	0.8	1.1	0.8	0.5	0.3	0.5	0.5	0.3	0.3	27		
28	0.8	0.8	1.7	2.2	0.3	0.8	1.1	0.8	0.6	0.3	0.6	0.6	0.3	0.3	28		
29	0.9	0.9	1.7	2.3	0.3	0.9	1.2	0.9	0.6	0.3	0.6	0.6	0.3	0.3	29		
30	0.9	0.9	1.8	2.4	0.3	0.9	1.2	0.9	0.6	0.3	0.6	0.6	0.3	0.3	30		

APPENDIX VII
A.A. FACTORS AND PRODUCTS—TEMPERATURE

Difference from Standard, °F.	1,000 ft. layer												3,000 ft. layer												Difference from Standard °F.
	Height of vertex (ft.)												Height of vertex (ft.)												
	4,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	4,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000					
1	0.71	0.37	0.25	0.16	0.12	0.09	0.07	0.07	0.06	0.05	0.26	0.30	0.21	0.16	0.12	0.09	0.07	0.06	0.05	0.04	1				
2	1.4	0.7	0.5	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.5	0.6	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	2				
3	2.1	1.1	0.7	0.5	0.4	0.3	0.2	0.2	0.2	0.1	0.8	0.9	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.2	3				
4	2.8	1.5	1.0	0.6	0.5	0.4	0.3	0.3	0.3	0.2	1.0	1.2	0.8	0.6	0.5	0.4	0.3	0.2	0.3	0.2	4				
5	3.5	1.9	1.3	0.8	0.6	0.5	0.3	0.3	0.3	0.3	1.3	1.5	1.1	0.8	0.6	0.5	0.3	0.3	0.3	0.2	5				
6	4.3	2.2	1.5	1.0	0.7	0.5	0.4	0.4	0.4	0.3	1.6	1.8	1.3	1.0	0.7	0.5	0.4	0.4	0.3	0.2	6				
7	5.0	2.6	1.7	1.1	0.8	0.6	0.5	0.5	0.4	0.3	1.8	2.1	1.5	1.1	0.8	0.6	0.5	0.4	0.3	0.3	7				
8	5.7	3.0	2.0	1.3	1.0	0.7	0.6	0.6	0.5	0.4	2.1	2.4	1.7	1.3	1.0	0.7	0.6	0.5	0.4	0.3	8				
9	6.4	3.3	2.3	1.4	1.1	0.8	0.6	0.6	0.5	0.5	2.3	2.7	1.9	1.4	1.1	0.8	0.6	0.5	0.5	0.4	9				
10	7.1	3.7	2.5	1.6	1.2	0.9	0.7	0.7	0.6	0.5	2.6	3.0	2.1	1.6	1.2	0.9	0.7	0.6	0.5	0.4	10				
11	7.8	4.1	2.7	1.8	1.3	1.0	0.8	0.8	0.7	0.5	2.9	3.3	2.3	1.8	1.3	1.0	0.8	0.7	0.5	0.4	11				
12	8.5	4.4	3.0	1.9	1.4	1.1	0.8	0.8	0.7	0.6	3.1	3.6	2.5	1.9	1.4	1.1	0.8	0.7	0.6	0.5	12				
13	9.2	4.8	3.3	2.1	1.6	1.2	0.9	0.9	0.8	0.7	3.4	3.9	2.7	2.1	1.6	1.2	0.9	0.8	0.7	0.5	13				
14	9.9	5.2	3.5	2.2	1.7	1.3	1.0	1.0	0.8	0.7	3.6	4.2	2.9	2.2	1.7	1.3	1.0	0.8	0.7	0.6	14				
15	10.7	5.5	3.7	2.4	1.8	1.3	1.1	1.1	0.9	0.7	3.9	4.5	3.1	2.4	1.8	1.3	1.1	0.9	0.7	0.6	15				
16	11.4	5.9	4.0	2.6	1.9	1.4	1.1	1.1	1.0	0.8	4.2	4.8	3.4	2.6	1.9	1.4	1.1	1.0	0.8	0.6	16				
17	12.1	6.3	4.3	2.7	2.0	1.5	1.2	1.2	1.0	0.9	4.4	5.1	3.6	2.7	2.0	1.5	1.2	1.0	0.9	0.7	17				
18	12.8	6.7	4.5	2.9	2.2	1.6	1.3	1.3	1.1	0.9	4.7	5.4	3.8	2.9	2.2	1.6	1.3	1.1	0.9	0.7	18				
19	13.5	7.0	4.7	3.0	2.3	1.7	1.3	1.3	1.1	0.9	4.9	5.7	4.0	3.0	2.3	1.7	1.3	1.1	0.9	0.8	19				
20	14.2	7.4	5.0	3.2	2.4	1.8	1.4	1.4	1.2	1.0	5.2	6.0	4.2	3.2	2.4	1.8	1.4	1.2	1.0	0.8	20				
21	14.9	7.8	5.3	3.4	2.5	1.9	1.5	1.5	1.3	1.1	5.5	6.3	4.4	3.4	2.5	1.9	1.5	1.3	1.1	0.8	21				
22	15.6	8.1	5.5	3.5	2.6	2.0	1.5	1.5	1.3	1.1	5.7	6.6	4.6	3.5	2.6	2.0	1.5	1.3	1.1	0.9	22				
23	16.3	8.5	5.7	3.7	2.8	2.1	1.6	1.6	1.4	1.1	6.0	6.9	4.8	3.7	2.8	2.1	1.6	1.4	1.1	0.9	23				
24	17.0	8.9	6.0	3.8	2.9	2.2	1.7	1.7	1.4	1.2	6.2	7.2	5.0	3.8	2.9	2.2	1.7	1.4	1.2	1.0	24				
25	17.7	9.3	6.3	4.0	3.0	2.3	1.7	1.7	1.5	1.3	6.5	7.5	5.3	4.0	3.0	2.3	1.7	1.5	1.3	1.0	25				
26	18.5	9.6	6.5	4.2	3.1	2.3	1.8	1.8	1.6	1.3	6.8	7.8	5.5	4.2	3.1	2.3	1.8	1.6	1.3	1.0	26				
27	19.2	10.0	6.7	4.3	3.2	2.4	1.9	1.9	1.6	1.3	7.0	8.1	5.7	4.3	3.2	2.4	1.9	1.6	1.3	1.1	27				
28	19.9	10.4	7.0	4.5	3.4	2.5	2.0	2.0	1.7	1.4	7.3	8.4	5.9	4.5	3.4	2.5	2.0	1.7	1.4	1.1	28				
29	20.6	10.7	7.3	4.6	3.5	2.6	2.0	2.0	1.7	1.5	7.5	8.7	6.1	4.6	3.5	2.6	2.0	1.7	1.5	1.2	29				
30	21.3	11.1	7.5	4.8	3.6	2.7	2.1	2.1	1.8	1.5	7.8	9.0	6.3	4.8	3.6	2.7	2.1	1.8	1.5	1.2	30				

APPENDIX VII—continued
A.A. FACTORS AND PRODUCTS—TEMPERATURE

Difference from Standard. ° F.	5,000 ft. layer												7,000 ft. layer												Difference from Standard. ° F.
	Height of vertex (ft.)												Height of vertex (ft.)												
	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000							
1	0.20	0.17	0.15	0.12	0.09	0.07	0.06	0.06	0.04	0.05	0.12	0.13	0.11	0.08	0.06	0.06	0.06	0.04	1						
2	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.1	0.1	0.1	0.1	2						
3	0.6	0.5	0.5	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.1	3						
4	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.5	0.5	0.4	0.3	0.2	0.2	0.2	0.2	4						
5	1.0	0.9	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.3	0.6	0.7	0.5	0.4	0.3	0.3	0.3	0.2	5						
6	1.2	1.0	0.9	0.7	0.5	0.4	0.4	0.4	0.2	0.3	0.7	0.8	0.7	0.5	0.4	0.4	0.4	0.2	6						
7	1.4	1.2	1.1	0.8	0.6	0.5	0.4	0.4	0.3	0.3	0.8	0.9	0.8	0.6	0.4	0.4	0.4	0.3	7						
8	1.6	1.4	1.2	1.0	0.7	0.6	0.5	0.5	0.3	0.4	1.0	1.0	0.9	0.6	0.5	0.5	0.5	0.3	8						
9	1.8	1.5	1.3	1.1	0.8	0.6	0.5	0.5	0.4	0.5	1.1	1.2	1.0	0.7	0.5	0.5	0.5	0.4	9						
10	2.0	1.7	1.5	1.2	0.9	0.7	0.6	0.6	0.4	0.5	1.2	1.3	1.1	0.8	0.6	0.6	0.6	0.4	10						
11	2.2	1.9	1.7	1.3	1.0	0.8	0.7	0.7	0.4	0.5	1.3	1.4	1.2	0.9	0.7	0.7	0.7	0.4	11						
12	2.4	2.0	1.8	1.4	1.1	0.8	0.7	0.7	0.5	0.6	1.4	1.6	1.3	1.0	0.7	0.7	0.7	0.5	12						
13	2.6	2.2	1.9	1.6	1.2	0.9	0.8	0.8	0.5	0.7	1.6	1.7	1.4	1.0	0.8	0.8	0.8	0.5	13						
14	2.8	2.4	2.1	1.7	1.3	1.0	0.8	0.8	0.6	0.7	1.7	1.8	1.5	1.1	0.8	0.8	0.8	0.6	14						
15	3.0	2.5	2.3	1.8	1.3	1.1	0.9	0.9	0.6	0.7	1.8	1.9	1.7	1.2	0.9	0.9	0.9	0.6	15						
16	3.2	2.7	2.4	1.9	1.4	1.1	1.0	1.0	0.6	0.8	1.9	2.1	1.8	1.3	1.0	1.0	1.0	0.6	16						
17	3.4	2.9	2.5	2.0	1.5	1.2	1.0	1.0	0.7	0.9	2.0	2.2	1.9	1.4*	1.0	1.0	1.0	0.7	17						
18	3.6	3.1	2.7	2.2	1.6	1.3	1.1	1.1	0.7	0.9	2.2	2.3	2.0	1.4	1.1	1.1	1.1	0.7	18						
19	3.8	3.2	2.9	2.3	1.7	1.3	1.1	1.1	0.8	0.9	2.3	2.5	2.1	1.5	1.1	1.1	1.1	0.8	19						
20	4.0	3.4	3.0	2.4	1.8	1.4	1.2	1.2	0.8	1.0	2.4	2.6	2.2	1.6	1.2	1.2	1.2	0.8	20						
21	4.2	3.6	3.1	2.5	1.9	1.5	1.3	1.3	0.8	1.1	2.5	2.7	2.3	1.7	1.3	1.3	1.3	0.8	21						
22	4.4	3.7	3.3	2.6	2.0	1.5	1.3	1.3	0.9	1.1	2.6	2.9	2.4	1.8	1.3	1.3	1.3	0.9	22						
23	4.6	3.9	3.5	2.8	2.1	1.6	1.4	1.4	0.9	1.1	2.8	3.0	2.5	1.8	1.4	1.4	1.4	0.9	23						
24	4.8	4.1	3.6	2.9	2.2	1.7	1.4	1.4	1.0	1.2	2.9	3.1	2.6	1.9	1.4	1.4	1.4	1.0	24						
25	5.0	4.3	3.7	3.0	2.3	1.7	1.5	1.5	1.0	1.3	3.0	3.3	2.7	2.0	1.5	1.5	1.5	1.0	25						
26	5.2	4.4	3.9	3.1	2.3	1.8	1.6	1.6	1.0	1.3	3.1	3.4	2.9	2.1	1.6	1.6	1.6	1.0	26						
27	5.4	4.6	4.1	3.2	2.4	1.9	1.6	1.6	1.1	1.3	3.2	3.5	3.0	2.2	1.6	1.6	1.6	1.1	27						
28	5.6	4.8	4.2	3.4	2.5	2.0	1.7	1.7	1.1	1.4	3.4	3.6	3.1	2.2	1.7	1.7	1.7	1.1	28						
29	5.8	4.9	4.3	3.5	2.6	2.0	1.7	1.7	1.2	1.5	3.5	3.8	3.2	2.3	1.7	1.7	1.7	1.2	29						
30	6.0	5.1	4.5	3.6	2.7	2.1	1.8	1.8	1.2	1.5	3.6	3.9	3.3	2.4	1.8	1.8	1.8	1.2	30						

APPENDIX VII—continued
A.A. FACTORS AND PRODUCTS—TEMPERATURE

Difference from Standard. ° F.	9,000 ft. layer								11,000 ft. layer								Difference from Standard. ° F.
	Height of vertex (ft.)								Height of vertex (ft.)								
	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000	
1	0.08	0.10	0.09	0.08	0.06	0.06	0.05	0.04	0.03	0.07	0.08	0.07	0.06	0.06	0.04	0.04	1
2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	2
3	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	3
4	0.3	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.3	0.3	0.3	0.2	0.2	0.2	0.2	4
5	0.4	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.1	0.3	0.4	0.3	0.3	0.3	0.2	0.2	5
6	0.5	0.6	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.4	0.5	0.4	0.4	0.4	0.2	0.2	6
7	0.6	0.7	0.6	0.6	0.4	0.4	0.3	0.3	0.2	0.5	0.6	0.5	0.4	0.4	0.3	0.3	7
8	0.6	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.2	0.6	0.6	0.6	0.5	0.5	0.3	0.3	8
9	0.7	0.9	0.8	0.7	0.5	0.5	0.5	0.4	0.3	0.6	0.7	0.6	0.5	0.5	0.4	0.4	9
10	0.8	1.0	0.9	0.8	0.6	0.6	0.5	0.4	0.3	0.7	0.8	0.7	0.6	0.6	0.4	0.4	10
11	0.9	1.1	1.0	0.9	0.7	0.7	0.5	0.4	0.3	0.8	0.9	0.8	0.7	0.7	0.4	0.4	11
12	1.0	1.2	1.1	1.0	0.7	0.7	0.6	0.5	0.4	0.8	1.0	0.8	0.7	0.7	0.5	0.5	12
13	1.0	1.3	1.2	1.0	0.8	0.8	0.7	0.5	0.4	0.9	1.0	0.9	0.8	0.8	0.5	0.5	13
14	1.1	1.4	1.3	1.1	0.8	0.8	0.7	0.6	0.4	1.0	1.1	1.0	0.8	0.8	0.6	0.6	14
15	1.2	1.5	1.3	1.2	0.9	0.9	0.7	0.6	0.5	1.1	1.2	1.1	0.9	0.9	0.6	0.6	15
16	1.3	1.6	1.4	1.3	1.0	1.0	0.8	0.6	0.5	1.1	1.3	1.1	1.0	1.0	0.6	0.6	16
17	1.4	1.7	1.5	1.4	1.0	1.0	0.9	0.7	0.5	1.2	1.4	1.2	1.0	1.0	0.7	0.7	17
18	1.4	1.8	1.6	1.4	1.1	1.1	0.9	0.7	0.5	1.3	1.4	1.3	1.1	1.1	0.7	0.7	18
19	1.5	1.9	1.7	1.5	1.1	1.1	0.9	0.8	0.6	1.3	1.5	1.3	1.1	1.1	0.8	0.8	19
20	1.6	2.0	1.8	1.6	1.2	1.2	1.0	0.8	0.6	1.4	1.6	1.4	1.2	1.2	0.8	0.8	20
21	1.7	2.1	1.9	1.7	1.3	1.3	1.1	0.8	0.6	1.5	1.7	1.5	1.3	1.3	0.8	0.8	21
22	1.8	2.2	2.0	1.8	1.3	1.3	1.1	0.9	0.7	1.5	1.8	1.5	1.3	1.3	0.9	0.9	22
23	1.8	2.3	2.1	1.8	1.4	1.4	1.1	0.9	0.7	1.6	1.8	1.6	1.4	1.4	0.9	0.9	23
24	1.9	2.4	2.2	1.9	1.4	1.4	1.2	1.0	0.7	1.7	1.9	1.7	1.4	1.4	1.0	1.0	24
25	2.0	2.5	2.3	2.0	1.5	1.5	1.3	1.0	0.7	1.7	2.0	1.7	1.5	1.5	1.0	1.0	25
26	2.1	2.6	2.3	2.1	1.6	1.6	1.3	1.0	0.8	1.8	2.1	1.8	1.6	1.6	1.0	1.0	26
27	2.2	2.7	2.4	2.2	1.6	1.6	1.3	1.1	0.8	1.9	2.2	1.9	1.6	1.6	1.1	1.1	27
28	2.2	2.8	2.5	2.2	1.7	1.7	1.4	1.1	0.8	2.0	2.2	2.0	1.7	1.7	1.1	1.1	28
29	2.3	2.9	2.6	2.3	1.7	1.7	1.5	1.2	0.9	2.0	2.3	2.0	1.7	1.7	1.2	1.2	29
30	2.4	3.0	2.7	2.4	1.8	1.8	1.5	1.2	0.9	2.1	2.4	2.1	1.8	1.8	1.2	1.2	30

APPENDIX VII—continued
A.A. FACTORS AND PRODUCTS—TEMPERATURE

Difference from Standard. ° F.	13,000 ft. layer								15,000 ft. layer								Difference from Standard. ° F.
	Height of vertex (ft.)								Height of vertex (ft.)								
	16,000	20,000	24,000	28,000	32,000	36,000	40,000	16,000	20,000	24,000	28,000	32,000	36,000	40,000			
1	0.05	0.06	0.06	0.06	0.06	0.05	0.04	0.01	0.05	0.06	0.05	0.05	0.05	0.05	0.04	1	
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2	
3	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	3	
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	4	
5	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.2	5	
6	0.3	0.4	0.4	0.4	0.4	0.3	0.2	0.1	0.3	0.4	0.3	0.3	0.3	0.3	0.2	6	
7	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.1	0.3	0.4	0.3	0.3	0.3	0.3	0.3	7	
8	0.4	0.5	0.5	0.5	0.5	0.4	0.3	0.1	0.4	0.5	0.4	0.4	0.4	0.4	0.3	8	
9	0.5	0.5	0.5	0.5	0.6	0.5	0.4	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.4	9	
10	0.5	0.6	0.6	0.6	0.6	0.5	0.4	0.1	0.5	0.6	0.5	0.5	0.5	0.5	0.4	10	
11	0.5	0.7	0.7	0.7	0.7	0.5	0.4	0.1	0.5	0.7	0.5	0.5	0.5	0.5	0.4	11	
12	0.6	0.7	0.7	0.7	0.7	0.6	0.5	0.1	0.6	0.7	0.6	0.6	0.6	0.6	0.5	12	
13	0.7	0.8	0.8	0.8	0.8	0.7	0.5	0.1	0.7	0.8	0.7	0.7	0.7	0.7	0.5	13	
14	0.7	0.8	0.8	0.8	0.8	0.7	0.6	0.1	0.7	0.8	0.7	0.7	0.7	0.7	0.6	14	
15	0.7	0.9	0.9	0.9	0.9	0.7	0.6	0.1	0.7	0.9	0.7	0.7	0.7	0.7	0.6	15	
16	0.8	1.0	1.0	1.0	1.0	0.8	0.6	0.2	0.8	1.0	0.8	0.8	0.8	0.8	0.6	16	
17	0.9	1.0	1.0	1.0	1.0	0.9	0.7	0.2	0.9	1.0	0.9	0.9	0.9	0.9	0.7	17	
18	0.9	1.1	1.1	1.1	1.1	0.9	0.7	0.2	0.9	1.1	0.9	0.9	0.9	0.9	0.7	18	
19	0.9	1.1	1.1	1.1	1.1	0.9	0.8	0.2	0.9	1.1	0.9	0.9	0.9	0.9	0.8	19	
20	1.0	1.2	1.2	1.2	1.2	1.0	0.8	0.2	1.0	1.2	1.0	1.0	1.0	1.0	0.8	20	
21	1.1	1.3	1.3	1.3	1.3	1.1	0.8	0.2	1.1	1.3	1.1	1.1	1.1	1.1	0.8	21	
22	1.1	1.3	1.3	1.3	1.3	1.1	0.9	0.2	1.1	1.3	1.1	1.1	1.1	1.1	0.9	22	
23	1.1	1.4	1.4	1.4	1.4	1.1	0.9	0.2	1.1	1.4	1.1	1.1	1.1	1.1	0.9	23	
24	1.2	1.4	1.4	1.4	1.4	1.2	1.0	0.2	1.2	1.4	1.2	1.2	1.2	1.2	1.0	24	
25	1.3	1.5	1.5	1.5	1.5	1.3	1.0	0.3	1.3	1.5	1.3	1.3	1.3	1.3	1.0	25	
26	1.3	1.6	1.6	1.6	1.6	1.3	1.0	0.3	1.3	1.6	1.3	1.3	1.3	1.3	1.0	26	
27	1.3	1.6	1.6	1.6	1.6	1.3	1.1	0.3	1.3	1.6	1.3	1.3	1.3	1.3	1.1	27	
28	1.4	1.7	1.7	1.7	1.7	1.4	1.1	0.3	1.4	1.7	1.4	1.4	1.4	1.4	1.1	28	
29	1.5	1.7	1.7	1.7	1.7	1.5	1.2	0.3	1.5	1.7	1.5	1.5	1.5	1.5	1.2	29	
30	1.5	1.8	1.8	1.8	1.8	1.5	1.2	*0.3	1.5	1.8	1.5	1.5	1.5	1.5	1.2	30	

APPENDIX VII—continued
A.A. FACTORS AND PRODUCTS—TEMPERATURE

Difference from Standard ° F.	18,000 ft. layer					22,000 ft. layer					Difference from Standard ° F.	
	Height of vertex (ft.)					Height of vertex (ft.)						
	20,000	24,000	28,000	32,000	36,000	40,000	24,000	28,000	32,000	36,000		40,000
1	0.05	0.08	0.09	0.09	0.08	0.08	0.03	0.07	0.05	0.06	0.07	1
2	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	2
3	0.1	0.2	0.3	0.3	0.2	0.2	0.1	0.2	0.1	0.2	0.2	3
4	0.2	0.3	0.4	0.4	0.3	0.3	0.1	0.3	0.2	0.2	0.3	4
5	0.3	0.4	0.5	0.5	0.4	0.4	0.1	0.3	0.3	0.3	0.3	5
6	0.3	0.5	0.5	0.5	0.5	0.5	0.2	0.4	0.3	0.4	0.4	6
7	0.3	0.6	0.6	0.6	0.6	0.6	0.2	0.5	0.3	0.4	0.5	7
8	0.4	0.6	0.7	0.7	0.6	0.6	0.2	0.6	0.4	0.5	0.6	8
9	0.5	0.7	0.8	0.8	0.7	0.7	0.3	0.6	0.5	0.5	0.6	9
10	0.5	0.8	0.9	0.9	0.8	0.8	0.3	0.7	0.5	0.6	0.7	10
11	0.5	0.9	1.0	1.0	0.9	0.9	0.3	0.8	0.5	0.7	0.8	11
12	0.6	1.0	1.1	1.1	1.0	1.0	0.4	0.8	0.6	0.7	0.8	12
13	0.7	1.0	1.2	1.2	1.0	1.0	0.4	0.9	0.7	0.8	0.9	13
14	0.7	1.1	1.3	1.3	1.1	1.1	0.4	1.0	0.7	0.8	1.0	14
15	0.7	1.2	1.3	1.3	1.2	1.2	0.5	1.1	0.7	0.9	1.1	15
16	0.8	1.3	1.4	1.4	1.3	1.3	0.5	1.1	0.8	1.0	1.1	16
17	0.9	1.4	1.5	1.5	1.4	1.4	0.5	1.2	0.9	1.0	1.2	17
18	0.9	1.4	1.6	1.6	1.4	1.4	0.5	1.3	0.9	1.1	1.3	18
19	0.9	1.5	1.7	1.7	1.5	1.5	0.6	1.3	0.9	1.1	1.3	19
20	1.0	1.6	1.8	1.8	1.6	1.6	0.6	1.4	1.0	1.2	1.4	20
21	1.1	1.7	1.9	1.9	1.7	1.7	0.6	1.5	1.1	1.3	1.5	21
22	1.1	1.8	2.0	2.0	1.8	1.8	0.7	1.5	1.1	1.3	1.5	22
23	1.1	1.8	2.1	2.1	1.8	1.8	0.7	1.6	1.1	1.4	1.6	23
24	1.2	1.9	2.2	2.2	1.9	1.9	0.7	1.7	1.2	1.4	1.7	24
25	1.3	2.0	2.3	2.3	2.0	2.0	0.7	1.7	1.3	1.5	1.7	25
26	1.3	2.1	2.3	2.3	2.1	2.1	0.8	1.8	1.3	1.6	1.8	26
27	1.3	2.2	2.4	2.4	2.2	2.2	0.8	1.9	1.3	1.6	1.9	27
28	1.4	2.2	2.5	2.5	2.2	2.2	0.8	2.0	1.4	1.7	2.0	28
29	1.5	2.3	2.6	2.6	2.3	2.3	0.9	2.0	1.5	1.7	2.0	29
30	1.5	2.4	2.7	2.7	2.4	2.4	0.9	2.1	1.5	1.8	2.1	30

APPENDIX VII—continued
A.A. FACTORS AND PRODUCTS—TEMPERATURE

Difference from Standard ° F.	26,000 ft. layer				30,000 ft. layer			34,000 ft. layer		38,000 ft. layer		Difference from Standard ° F.
	Height of vertex (ft.)				Height of vertex (ft.)			Height of vertex (ft.)		Height of vertex (ft.)		
	28,000	32,000	36,000	40,000	32,000	36,000	40,000	36,000	40,000	40,000	40,000	
1	0.03	0.03	0.04	0.05	0.02	0.02	0.03	0.02	0.02	0.01	1	
2	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	2	
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	3	
4	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	4	
5	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1	5	
6	0.2	0.2	0.2	0.3	0.1	0.1	0.2	0.1	0.1	0.1	6	
7	0.2	0.2	0.3	0.3	0.1	0.1	0.2	0.1	0.1	0.1	7	
8	0.2	0.2	0.3	0.4	0.2	0.2	0.2	0.2	0.2	0.1	8	
9	0.3	0.3	0.4	0.5	0.2	0.2	0.3	0.2	0.2	0.1	9	
10	0.3	0.3	0.4	0.5	0.2	0.2	0.3	0.2	0.2	0.1	10	
11	0.3	0.3	0.4	0.5	0.2	0.2	0.3	0.2	0.2	0.1	11	
12	0.4	0.4	0.5	0.6	0.2	0.2	0.4	0.2	0.2	0.1	12	
13	0.4	0.4	0.5	0.7	0.3	0.3	0.4	0.3	0.3	0.1	13	
14	0.4	0.4	0.6	0.7	0.3	0.3	0.4	0.3	0.3	0.1	14	
15	0.5	0.5	0.6	0.7	0.3	0.3	0.5	0.3	0.3	0.1	15	
16	0.5	0.5	0.6	0.8	0.3	0.3	0.5	0.3	0.3	0.2	16	
17	0.5	0.5	0.7	0.9	0.3	0.3	0.5	0.3	0.3	0.2	17	
18	0.5	0.5	0.7	0.9	0.4	0.4	0.5	0.4	0.4	0.2	18	
19	0.6	0.6	0.8	0.9	0.4	0.4	0.6	0.4	0.4	0.2	19	
20	0.6	0.6	0.8	1.0	0.4	0.4	0.6	0.4	0.4	0.2	20	
21	0.6	0.6	0.8	1.1	0.4	0.4	0.6	0.4	0.4	0.2	21	
22	0.7	0.7	0.9	1.1	0.4	0.4	0.7	0.4	0.4	0.2	22	
23	0.7	0.7	0.9	1.1	0.5	0.5	0.7	0.5	0.5	0.2	23	
24	0.7	0.7	1.0	1.2	0.5	0.5	0.7	0.5	0.5	0.2	24	
25	0.7	0.7	1.0	1.3	0.5	0.5	0.7	0.5	0.5	0.3	25	
26	0.8	0.8	1.0	1.3	0.5	0.5	0.8	0.5	0.5	0.3	26	
27	0.8	0.8	1.1	1.3	0.5	0.5	0.8	0.5	0.5	0.3	27	
28	0.8	0.8	1.1	1.4	0.6	0.6	0.8	0.6	0.6	0.3	28	
29	0.9	0.9	1.2	1.5	0.6	0.6	0.9	0.6	0.6	0.3	29	
30	0.9	0.9	1.2	1.5	0.6	0.6	0.9	0.6	0.6	0.3	30	

